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A Summary of Current Program, 7/1/62

and Preliminary Report of Progress

for 7/1/60 to 6/30/62

ANIMAL HUSBANDRY RESEARCH DIVISION

of the

AGRICULTURAL RESEARCH SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE

This progress report of U.S.D.A. and cooperative research is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

There is included under each problem area in the report a brief and very general statement on the nature of the research being conducted by the State agricultural experiment stations and the professional manpower being devoted by the State stations to such research. Also included is a brief description of related work conducted by private organizations. No details on progress of State station or industry research are included except as such work is cooperative with U.S.D.A.

The summaries of progress on U.S.D.A. and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having a special interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of U.S.D.A. and cooperative research issued between July 1, 1960, and June 30, 1962. Current agricultural research findings are also published in the monthly U.S.D.A. publication, Agricultural Research. This progress report was compiled in the Animal Husbandry Research Division, Agricultural Research Service, U. S. Department of Agriculture, Beltsville, Md.

UNITED STATES DEPARTMENT OF AGRICULTURE

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INTRODUCTION

The important contribution of livestock production to a progressive agricultural industry and a well nourished society is indisputable. In 1960 there were 109,364,000 feed-consuming animal units kept for producing animal food and fiber on American farms. This animal population consumed the equivalent of 145.7 million tons of concentrates and 119.3 million tons of roughage, including pasture. To grow this feed required over 200 million acres of cropland and more than 1200 million acres of pasture and range. Livestock production continues to be the most effective way to market a great part of the product of the soil. The products of livestock account for 56% of the gross farm income. Animal products contribute more than one-third the food energy and nearly two-thirds of the protein in the total food supply.

Livestock farming is characteristically a family farm enterprise, offering possibilities for diversification and balanced, conservation-type farming. The production of those livestock products for which the supply does not meet the consumer demand can provide alternative farm enterprises to the continued production of many crops for which the supply exceeds the demand. Small-scale livestock farming is a source of additional cash receipts to many persons who obtain part of their income from nonagricultural sources.

Livestock production is faced with many problems that only further intensified research can solve. Output per animal unit has increased steadily over the last decade but it has not kept pace with other agricultural enterprises. Yield per acre for feed grains from 1950-61 increased 52%; livestock production per breeding unit increased only 29%. Production per man-hour has increased 94% for all crops; for livestock and their products only 48%. The critical problem of producing animal foods, meat and milk especially, with less fat but with improvements in other desirable qualities is yet to be solved. Output per animal has increased but the efficiency of feed conversion has changed very little. The low reproductive efficiency and excessive young animal mortality are causing approximately a 30% loss to livestock producers. The identification, development, and evaluation of superior germ plasm in all classes of farm animals must be improved and superior animals used more extensively to improve the efficiency of production, particularly in regard to feed conversion. The protection of animals and their products through wise use of chemicals, feed additives, and other materials must be assured through research.

Solutions to these problems will benefit individual farmers by lowering costs and increasing net income. They will improve the utilization

of the surplus grain supply. They will benefit the public through lower-cost animal foods and an assured supply of high quality foods more suited to their needs. More efficient high producing animals of the various classes will aid the small farmer particularly, permitting a more diversified enterprise. They will lend substance to rural area development programs by making livestock farming on a small-scale more attractive. Research in livestock production also offers opportunity to develop ways of managing and feeding at levels that might be less than the maximum possible and with as great returns, thus adjusting output more closely to market needs.

The investigations of the Animal Husbandry Research Division are directed towards the previously mentioned problems of the livestock industry as well as the development of new scientific knowledge which will contribute to solving future problems. The effort is carried out by a staff of about 300 persons of whom 157 are professional research scientists. The work is conducted in facilities at Beltsville and at field locations throughout the United States. Many of the projects are carried out cooperatively with State agricultural experiment stations. Investigations are carried on in genetics and breeding, nutrition and feeding, feed composition and evaluation, anatomy, physiology, and management that relate to growth, development, reproduction and production of beef and dairy cattle, poultry, sheep, swine and fur bearing animals. Pioneering research laboratories at Beltsville and Lafayette, Indiana, are conducting basic studies on blood antigens and animal genetics. National cooperative record of performance programs are conducted with dairy cattle to identify and evaluate superior sires, and with chickens and turkeys to evaluate breeding stocks. Research also is conducted on methods of humane slaughter of livestock; on the quality of meat, milk and eggs, as influenced by production factors; on the basic metabolism in the animal body of pesticides, hormones and other chemicals used in agricultural production and the effects of these chemicals on animal products; and on the prevention of avian leukosis in poultry.

The contributions of Division scientists to basic research knowledge and the solving of problems in the livestock industry have been too numerous to discuss here. Some which have received widespread recognition are studies on the genetics of the guinea pig, open-faced sheep, proved dairy sires, development of new breeds, records of performance, parthenogenesis of turkeys, adaptability of cattle to adverse climates, nutritional requirements, forage utilization, avian leukosis, and techniques for evaluating product quality. Mentioned briefly below are a few of the more recent developments which have made marked contributions to the industry and to their fields of research.

Sheep breeding. Sheep breeders are taking advantage of improved strains and breeding systems for producing more efficient farm and range sheep. The value and use of Targhee sheep, long established in the Western and Southwestern range areas of the U. S., has been tested in Hawaii and this USDA developed breed was found superior to the other sheep commercially available in the area. The improvement was primarily in the production of heavier lambs at weaning time. Use of improved rams on the typical ewes of the Navajo Indian Reservation, in only two generations, nearly doubled the production of grease wool; increased clean fleece weights as much as a third; and increased staple length as much as forty percent. After three or four generations, weaning weights of lambs had increased by 10 to 25%. The Columbia-Southdale strain, being developed as a dual purpose sheep under Eastern United States farm conditions, is already performing favorably as compared to other breeds used in the trials. Crossbreeding research has established that lamb production per ewe can be increased as much as 30% in a three-breed rotation system. About 90% of lambs marketed for meat in the U. S. are crossbred.

Performance testing in beef cattle. In 1961, more than 308,000 cows in over 4,200 herds throughout the United States were enrolled in brood cow performance testing programs. More than 15,000 bulls were tested for gaining ability under feedlot conditions and at least 191 breeders are known to be following systematic progeny testing programs for carcass evaluation. Virtually all this industry application has occurred since 1954 and is a direct outgrowth of research initiated by the Department of Agriculture in 1930 and carried out through regional projects in cooperation with 35 State experiment stations since the late 1940's. Calculations based on heritability estimates and other genetic and phenotypic parameters developed as a result of this research work indicate that if universal application were made of performance testing techniques now available, the following improvements over a 10-year period would be possible: (1) increases in weaning weight of from 5 to 10%, (2) increases of more than 1/4 lb. in average daily gain post-weaning, which would be associated with a 6 to 8% saving in feed, and (3) moderate improvements in carcass lean content and tenderness and palatability of resulting beef.

Avian anatomy. AH scientists engaged in longtime investigations on avian anatomy published in 1961, the "Atlas of Avian Hematology." This publication has made available to poultrymen, veterinarians, and research workers an important new tool for study and diagnosis of abnormal blood-cell

conditions in chickens. Reviews of this work in scientific journals of this and other countries have praised the scientific and journalistic contribution of the work. Primarily because of his leadership in this study, Dr. A. M. Lucas of the Regional Poultry Research Laboratory recently received the Superior Service Award of the USDA, the Tom Newman Memorial International Award by the Poultry Association of Great Britain, and was selected as the first Honorary Member of the American Association of Veterinary Anatomists.

Meat-type hogs. Improved swine carcasses have been the goal of research by the USDA and cooperating State experiment stations through work at Beltsville, Md., and the Regional Swine Breeding Laboratory. As a result of these efforts, a growing number of markets are grading hogs on basis of USDA standards based on scientific data indicating the traits affecting pork quality. Breeding research has shown that the yield of lean cuts in meat-type hogs can be greater than 50% as compared to 44% in fat hogs. Very recent studies have shown that selection for low fat carcasses can decrease back fat thickness by 18% in 7 generations. The additional worth of meat-type animals to the farmer is estimated at \$5.00 per head. The percent of meat-type hogs marketed in the U. S. has risen from 17 in 1956 to 30 in 1961.

Low moisture silage. In recent years much of the hay crop forage used for silage contained from 65 to 80% moisture when stored. Nutrient losses during storage were frequently high and feeding trials consistently showed that these high moisture silages were not equal in feeding value to hay made from the same crop. The first breakthrough pointing the way to the adoption of new techniques which would overcome these deficiencies resulted from a series of trials which showed that silage, virtually equal in feeding value to good quality hay, could be produced if the forage was stored when it contained 50 to 55% moisture rather than 65 to 80%. Nutrient losses during storage were also reduced with this type of forage.

These first experimental silages were produced in gastight silos. Further studies using conventional silos demonstrated that this improved type of silage could be successfully made in any type of silo, which may be available, provided that the silo is made airtight. Inexpensive means for adequately sealing silos have been developed.

The usefulness of these findings has been recognized rapidly by producers of livestock feed. Five years ago high moisture

(haycrop) silage was predominant and production was declining because of the excessive storage losses and the shortcomings of the silage as feed. Now this trend has been completely reversed. Silage production from hay crops is increasing and low moisture silage (frequently referred to as Haylage) is becoming the predominant type.

AREA NO. 1 - ANIMAL BIOLOGY

Problem. The extent of applicable results in animal husbandry research is severely limited by a paucity of basic information on the genetics, nutrition and physiology of our livestock. The basic research in progress has resulted primarily in revealing the inadequacy of our information regarding the functional processes within the animals we are trying to control and develop for human use. Basic research is required in such fields as animal cell metabolism and reproduction, enzymology, physiological bases for heredity and microbiology of the rumen and intestines. Results of such studies provide the basis for additional research applied to the husbandry of each type of livestock.

USDA PROGRAM

This area consists of basic research conducted by geneticists, biochemists, physiologists, and nutritionists. It includes studies in the Pioneering Laboratories on somatic variations of red cell antigens, on the nature of the specificity of antigens and antibodies, and on methods and theories of population genetics. Research in reproductive physiology is in progress to determine the biochemical composition and the defensive mechanisms of the uterus. Still other physiological investigations are involved with the response of mammary tissue to invasion by infectious agents. One study of long standing has the primary objective of describing, fully and in detail, the gross and microscopic anatomy of the domesticated fowl. Research on the metabolic role of vitamin B₁₂, the investigation of unidentified nutrients in food and feed, and biological and chemical studies of rumen metabolism are also being undertaken. The work is conducted at Beltsville, Maryland, East Lansing, Michigan, and in cooperation with the Indiana, Maryland, Michigan, and Wisconsin Agricultural Experiment Stations.

The Federal scientific effort devoted to research in this area totals 11.2 professional man-years. Of these, 5.5 professional man-years are in genetics, 2.0 in nutrition, 3.5 in rumen function, and .2 in program leadership.

There are two grants involving Public Law 480 funds in foreign countries financing research related to animal biology. One is with the Polish Academy of Science, Jabtonna, Poland. The project is on the secretion of anterior pituitary hormones and ovulation in small ruminants and is supported for three years (1960-1962) by \$11,495 equivalent in Polish zlotys. The second project is with the Institute Espanol de Fisiologia y Bioquimica, Madrid, Spain, and is entitled "Study of Metabolism of Zinc in Living Organisms by Means of Zinc 65." It has a duration of four years (1961-1964) and is supported by \$35,277 equivalent in Spanish pesetas.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State experiment stations reported a total of 92.8 professional man-years of which 13.7 are in genetics, 19.1 in physiology, 41.3 in nutrition, and 18.6 in rumen function.

Drosophila, Tribolium, mice, guinea pigs, and other laboratory animals are being used to test genetic principles and new concepts in breeding systems. Blood group research includes work on the chemical nature of the antigen-antibody relationship as well as inheritance of serum proteins. Research designed to gain an understanding of fundamental physiological principles includes investigation of various phases of the problem of hormonal control of the reproductive process in the female. Other research is concerned with the overall problem of improving semen production, evaluation, and preservation. Additional physiological research is conducted on biochemical and fundamental physiological changes occurring with genetically variable growth and the relative significance of the various parts of the alimentary tract with respect to transfer of certain minerals.

The animal requirements for specific nutrients and various factors which influence nutrient requirements and utilization pathways are under investigation as follows: (1) Essential macro and micro mineral nutrients and the interrelations and interdependences among them. (2) The influence of factors such as vitamins, hormones, and antibiotics on animal metabolism as reflected by general growth, blood, and liver composition. (3) Nutritional factors involved in certain toxicity problems such as high molybdenum or high selenium levels in certain feeds together with the basic metabolic pathways concerned. (4) The metabolism in animal systems of various fission products.

The fundamental physical and chemical factors responsible for the development of the functioning rumen are under study as are the basic factors influencing the fermentation of feedstuffs in the rumen. The plant constituents which contribute to bloating and the physiological factors in the rumen which are involved in bloat are the primary factors being studied.

There is very little research by industry in the field of animal biology where the major objective is agricultural. A small amount of activity amounting to not more than one or two professional man-years has been undertaken on the effect of antibiotics as related to bloat and rumen digestion.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Genetics

1. Methods and Theories of Population Genetics.

Experimental evaluations of the methods and theories of population genetics are underway at Lafayette, Indiana, in cooperation with the Population Genetics Institute of Purdue University.

a. Tribolium Studies.

Detailed analyses of the effects of mating systems and selection methods on a heterotic trait of Tribolium castaneum, a flour beetle, have been completed. All combinations of two selection methods (mass and random) and the five mating systems (phenotypic assortative, phenotypic disassortative, inbreeding, outbreeding, and random) were investigated through eight generations in two replicates from the same foundation population. One-hundred twenty offspring from each of the twenty populations were individually measured for 14-day larval weight in each generation. A terminal test was made by repeating the two replications of the random mated - random selected subclass and by crossing the two replications from several of the subclasses of generation eight. Also, three mass-selected subclasses were continued in one replication through the twelfth generation. Results are based on mass (or individual) selection and random (or no) selection in closed populations reproduced from a maximum of twenty pairs of parents.

As reported previously, 14-day larval weight showed a high degree of hybrid vigor or heterosis (33.6%) in crosses of stock used to form the population. Heritability of 14-day larval weight in the initial untreated generation was estimated to be $.150 \pm .031$ from the regression of offspring on sire.

The average realized heritability in the mass-selected subclasses over the eight treated generations was .155. A large and highly significant maternal effect was proved to be present. This maternal effect caused a significant upward bias in heritabilities estimated from regression of offspring on dam and regression of offspring on midparent. Heritability did not change significantly over generations, and sex-linkage was not detected. There was no significant difference in heritability estimates between selection methods. Differences in heritability estimates among mating systems were significant only at the 10% level or probability, and apparently resulted from a differential effect of the maternal factor on estimates for assortative and disassortative mating. Realized heritabilities for both replications of the inbred mating system were significantly lower and realized heritability for one replication of the outbred mating system was significantly higher than average for the mass-selected subclass.

Analysis of mean larval weights of sexes in treatment groups over generations showed highly significant effects of selection method (S), mating system (M) and sex (D). Also highly significant were the interactions of generation (G) XS, GXM, SXM, and GXMxD. Analysis within each generation showed that only the sex difference was significant in the untreated generation, but the effects of S, M, and D were highly significant in every treated generation except that D was not significant in one generation. None of the interactions were significant in any generation except that SXM was significant in the last generation at the 5% level of probability.

Analysis over generations of the log transformations of subclass variances indicated no significant effect of sex, selection method or generation but a highly significant effect of mating system. Multiple comparisons of mating systems revealed that the inbred mating system had significantly larger variance than the other four mating systems. No other differences were significant. Because of the trait's low heritability, the expected increase of variance in assortative mating would be quite small and unlikely to be detected as a difference over all generations. However, this mating system did have the largest variance in generation eight.

The Newman-Keuls multiple comparison test was applied to the mean differences between subclasses of generation eight and the terminal test. Based on the average of the two replications of generation eight, the mass-selected outbred subclass showed a highly significant superiority for large larval weight in every comparison except those with the cross between its own two replications (not significant) and with the mass-selected, assortatively mated subclass (significant). These three groups were followed in order of merit by four mass-selected groups (random-mating, the cross of the two replications of inbred mating, disassortative mating and inbred mating) and all random-selected groups. Inbreeding showed a highly significant inferiority to all other mating systems under mass-selection. The cross between its replications ranked above (not significantly) only one other mating system without crossing. The cross of inbreds showed a highly significant amount of heterosis and a larger amount of superiority over the cross between the random-selected inbred replications. The latter cross also showed highly significant heterosis but this only recovered the loss due to inbreeding. This is shown by the exact equality of the crosses between replications of the random-selected inbred subclass and the random-selected, random-mated subclass. Inbreeding was no aid to selection as is shown by the fact that adjustment of the mass selected inbred subclass for loss due to inbreeding is insufficient to raise it to the level of the random-mated subclass.

It is important to note that the superiority of outbreeding over the other noninbred mating systems was not due to the small differences in inbreeding coefficients. For changing this trait, it does not appear

that phenotypic assortative, random and phenotypic disassortative mating were greatly different. They ranked in this order in generation eight but the former happened to be higher and the latter lower in the initial generation. Replications of these subclasses were not crossed in the terminal test. One replication of these subclasses, not different in generation eight, were continued through generation twelve. In generations eleven and twelve, the means for assortative mating were much larger than those for disassortative and random mating, and the differences were highly significant. The latter two systems appeared to be approaching a plateau after generation nine, but the number of generations is insufficient to warrant a conclusion.

b. Mice Studies.

Three cases of unusual reproduction have been observed in mice. Superfetation (conception during pregnancy) has been reported as a rare event in mice and most other mammals. Two of the cases involve the production of two litters after the female was separated from the male. Superfetation and delayed implantation is strongly indicated in one case and delayed implantation in the other. The third case probably resulted from superfetation, with or without a delay in implantation.

In the long-term experiment on selection for white from a colored strain of mice, eight dark-eyed all white males (no females) have now been obtained from seven different sires and eight different dams. One all white male produced an all white son. Thirty-nine full brothers and 26 full sisters of all white males show various amounts of color. Definite progress is being made toward the goal of an all white population which would be the ultimate limit of selection. This experiment was initiated at Mt. Hope farm by Dr. H. D. Goodale in 1931 and is being continued here. Individual mice which have descended from the colored foundation population without selection have from none to a few white hairs on the forehead with the balance of the integument being colored.

2. Basic Research on Blood Antigens and Antibodies.

a. The Nature of Antigenic Specificity.

Studies on the red cell agglutinin of chickens designated "Hi" were continued. Additional evidence was obtained that the "Hi" agglutinin is affected both by the action of estrogen and the genotype of the bird. The restriction of agglutinability to the red cells of sexually mature females suggested that injection of estrogen into males regardless of their age would result in the red blood cells of such birds becoming agglutinable. Furthermore the use of immature birds of either sex or adult males permitted additional data to be

obtained to determine whether the "Hi" agglutininogen is affected by heredity and if so to help determine the mode of inheritance.

Injections of diethylstilbestrol begun in genetically competent young chickens at one month of age or older or genetically competent males, regardless of age, resulted in the transformation of the red cells of these birds to a state in which they may be specifically agglutinated with extracts of Lathyrus cicera or Pisum arvense. Progeny test data best fit the hypothesis that the "Hi" agglutininogen is under the control of a single autosomal gene.

b. In Vitro Uptake of Fe⁵⁹ in Adult and Immature Human Red Cells.

Studies were initiated to determine whether Fe⁵⁹ could be incorporated into erythrocytes in vitro. Such a method was needed to follow the development and differentiation of avian red blood cells and in particular the "Hi" substance. In vitro incorporation of Fe⁵⁹ in chicken red cells as well as in turkey, pigeon, and human red cells was achieved using Ferric⁵⁹ citrate in the presence of oxygen. The incorporation appears to favor the young cells since the unlysed cell population which contain young cells predominantly demonstrated a greater degree of incorporation than did the initial cell population.

c. The Chemical Nature of Antigen Specificity.

Extracts were made from chicken red blood cells by treatment with alcohol in an attempt to isolate and purify the "Hi" agglutininogen. Fractions obtained by precipitation at cold temperatures, and from the dried alcoholic solution and residue were tested. The water soluble and insoluble components from the alcohol extracts did not possess inhibiting activity. However, the dry cell residue could still absorb agglutinin.

Using a similar technique human red blood cells of the A₁, B, O, and AB cell types were extracted and group specific material isolated. It appears that these substances are fairly active serologically, water soluble and nondialyzable. Isolation of a crude substance designated P₂ and a partially purified substance P₅ from each of the four blood types was achieved. The P₂ and P₅ substances are fairly stable, can survive heating at 100° C. for two hours but are completely inactivated by heating for two hours in 0.01 NHCl. Analyses of hydrolysates of the P₂ preparations reveal them to contain approximately 15% reducing sugar and 3% hexosamine. The P₅ fractions regardless of the type of blood cell from which they were derived yielded the same proportions of reducing substance, hexosamine, fucose, phosphorous and nitrogen confirming the studies of Koscielak and Zakrezewski, with A, B and AB bloods. The studies on human red blood cells was a dissertation presented as a partial requirement for a Master of Science degree at Georgetown University.

d. Model Studies on Antibody Specificity.

Studies were conducted to isolate and purify the agglutinins obtained from seed extracts of Phaseolus lunatus. Such extracts specifically agglutinate human A₁ and A₂ red blood cells. The use of chromatographic columns (DEAE diethyl amino ethyl cellulose) employing salt and/or pH gradient techniques established the presence of a minimum of four protein components which exhibit anti-A specific activity and two components lacking activity. Further rechromatographing, as well as analysis by vertical starch gel electrophoresis, resulted in the isolation of several dozen other components. Best results were obtained with carboxy-methyl cellulose and some preparations were obtained which were suitable for certain chemical analysis. Preliminary experiments conducted on several preparations show that all fractions so far tested contain hexosamine residues which vary in content from 2% to as much as 7% (mg hexosamine/mg protein). These results suggest the possibility that the effective charge on the protein molecule is largely determined by the hexosamine content. Thus, it may be visualized that these several protein moieties possess the property of a common specificity but fractionate as separate components on cellulose columns because they contain varying amounts of hexosamine complexed possibly to a common protein base.

Difficulties involved in the purification of anti-A agglutinins using conventional procedures prompted studies with human red cell stroma (ghosts) as an alternative method for purification. These absorption studies with ghosts became important for reasons other than purification per se when it was observed that antibodies could be fractionally eluted from ghosts at various temperatures. Subsequent experiments confirmed these observations.

The use of red blood cell membranes as antigen sources for the purification and study of antibodies by absorption and elution has not found wide application because of the difficulty of preparing them free of hemoglobin. A simple procedure has been developed in this laboratory which accomplishes the preparation of red blood cell membranes essentially free of contaminating hemoglobin. The method involves lysis of the red blood cells in a buffered solution with a surface active reagent, Triton X-100 and concentration of the cell membranes by centrifugation. Several washings are then required to remove hemoglobin. The "ghost" preparations under microscopic examination appear as translucent forms which retain a physical appearance similar to the parent whole red blood cell. No changes in antigenic specificity were observed in tests performed on them. Such red blood cell membranes free of hemoglobin makes possible a wide variety of applications for the purification and study of antibodies.

Experiments on absorption and elution of immune anti-A₁ antisera were carried out with A₁ and A₂ ghosts. It was possible to obtain fractions

of antibody at 56° C. which contained very little antibody capable of being eluted at 45° or 37° C. Similar purifications have also been obtained for fractions eluted at 37° C. Absorption and elution experiments have also been carried out with Phaseolus lunatus. In these experiments the agglutinin was washed free more readily following absorption suggesting that the energy required for thermal disruption of the bond with the A₂ antigen is considerably lower than that for the immune anti-A agglutinin.

These studies indicated that whereas the agglutinins and ghost preparations are relatively stable to heat, it is still possible to disrupt those bonds which are responsible for antigen-antibody combination. Further experiments were conducted using urea to test the possibility that hydrogen bonding plays a role in this combination. These preliminary studies show that hydrogen bonding effects cannot be excluded in antigen-antibody reactions.

B. Physiology

1. Avian Anatomy.

Many dissections, working drawings and descriptions have been completed for the various organ systems; however, most of the final art work remains to be done. Nearest to completion is the first volume of the series, which deals with the skin, feathers and other specialized structures of the surface of the body and is broken down into the following topics: (1) Topographic anatomy, (2) palpable underlying bony landmarks, (3) feather tracts of chicken, turkey, domestic duck, laboratory pigeon and quail, (4) feather types in each part of the body, (5) the pattern of feather muscles, (6) the details of muscle bundles between adjacent feathers, (7) sequence of development of many of the feathers of the body, (8) the time of molting of most of the feathers, (9) the distribution of nerves, arteries and veins from their central connections to all parts of the skin, feather muscles and dermal appendages, (10) the detailed structure of different parts of a feather, and in feathers from different regions of the body, (11) the microscopic study of the skin and all of its major structures, such as comb, wattles, ear lobes, claws, scales, etc., (12) the complex organization of a growing feather and finally (13) the distribution, growth, molting and significance of filoplumes.

A critical study of the gross lesions of turkeys suggestive of leukosis revealed that lymphoid and reticular cell hyperplasia resulted from subclinical blackhead infections or from the medication used to inhibit the progress of histomoniasis. Heretofore this hyperplasia or abnormal increase in the number of cells in turkeys had served as a potential basis for the condemnation of such birds at the time they were identified in processing plants.

This cooperative study on the part of the Agricultural Marketing Service and this Laboratory prompted a revision of the regulations used for inspection in processing plants, and the results have also been incorporated in the Poultry Inspector's Handbook. (AH e6-20, e6-26)

2. Composition of Uterine Tissue.

a. Ionic Composition of the Uterus in Cattle and Sheep.

Previous work had characterized the water and electrolyte composition of the uterine tissues of rabbits and cattle during various phases of the estrous cycle, during treatment with ovarian hormones and during pregnancy. These studies were completed and extended to sheep to ascertain the variation in electrolyte composition in this species. The endocrine state of ewes influenced the water and ion composition of the uterine endometrium and myometrium. Estrous and luteal-phase ewes had higher water concentrations in both tissues than did ovariectomized ewes. In the endometrium, extracellular water volumes and Na and Cl concentrations were highest in estrous, intermediate in luteal and lowest in ovariectomized ewes. In myometrium, variation in water content was similar to that in the endometrium. Extracellular water volume and Na content were lowest in estrous and highest in ovariectomized ewes, the opposite of values for the endometrium. Increasing age (varying from 1 to 10 years) was associated with a decrease in endometrial water content in estrous ewes ($r = -0.68$, $P < 0.01$) but not in luteal or ovariectomized ones. These associations suggest that the production or effect of ovarian hormones associated with estrous may be modified by age. The production or effect of ovarian hormones of the luteal phase are apparently not influenced by age. (AH h5-8)

b. Ionic Composition of the Rat Uterus During Tissue Growth.

The water and electrolyte changes in the rat uterus during the development of the artificial placenta, the deciduoma, were studied in detail to correlate temporal relationships during the early initial growth of decidual tissue (0, 24, 48, 72, and 96 hours after stimulation of the tissue). There is an immediate rapid H_2O imbibition, and a Na and Cl increase, changes which were maintained in all 3 groups during the first 48 hours. Thereafter, a different course of ionic events occurs in the rats with ovaries or progesterone treatment as compared to those without sources of ovarian hormones (ovariectomized). During the next 48 hours in the ovariectomized group the tissue recovers, i.e., the diameter, weight, Na, Cl and H_2O content decrease and approach control levels. In contrast, in the animals with progesterone (endogenous or exogenous), H_2O and ionic effects characteristic of tissue growth are superimposed upon the inflammatory phase

recovery effects. The rapid growth of new protoplasm masks any decrease in size of the uterus due to diminution of the inflammation. The Na and Cl increases are maintained as growth proceeds and the extracellular space is replaced with tissue. After an initial decrease, a marked increase in K, a cellular constituent is also noted. The high water concentration is maintained, but the fluid which was formerly extracellular shifts into the intracellular compartment. Thus, the new uterine tissue which develops during this period (48-96 hours) is of a different composition than that initially present, not only with regard to its proportion of endometrium and myometrium, but also with regard to hydration, extracellular and cellular constituents. The results of these investigations indicate that the early effects of inflammation are very similar to those of growth during the development of deciduoma. While these similarities would make it difficult to use one or more of these ionic growth parameters as an indicator of progesterone action and assay, they may indicate a common basis in the mechanism of hormone action, based upon permeability effects. Further work is in progress on the mediation of hormone action by histamine, an inflammatory agent, through alteration of membrane permeability. (AH h5-8)

c. Ionic Composition of the Rat Uterus and Placental Tissues During Pregnancy.

Previous work has been primarily concerned with characterization during the nonpregnant state. This study was undertaken to provide information on several uterine and placental constituents during pregnancy in the rat. Amounts of H_2O , Na, Cl, K, glycogen and histamine were determined at intervals of three days throughout gestation. Interdecidual uterine tissue became more hydrated during the latter half of pregnancy and the concentration of all the electrolytes studied also increased. This interdecidual tissue (largely myometrium) showed a steady rise in glycogen from day 9 to 21, there being a 6-fold increase in concentration at term. Histamine, on the other hand, decreased steadily in this tissue throughout pregnancy until at 21 days there was less than half of the initial value. Both the fetal and maternal portions of the placenta contained more H_2O than the interdecidual uterus, and the ions were generally lower. The maternal placental tissues showed a marked H_2O depletion on day 15 but partial recovery to former levels were evinced subsequently. A sharp drop in K level of the fetal placenta occurred at term. Both Cl and Na in the placental tissues tended to be low at day 15. Glycogen in the maternal placenta quadrupled during the last 8 days of pregnancy but during the same period the level of glycogen in the fetal placenta diminished to one-third of its earlier value. The histamine content of both placental tissues increased 2-3 times during the last half of pregnancy. (AH h5-)

d. Uterine Glycogen During Growth of Decidual Tissue.

The levels of glycogen, the principal storage form of carbohydrate energy, have been followed during the development of the artificial placenta, the deciduoma, in the rat. Previous work in other laboratories on uterine glycogen in rats indicated that estrogens cause glycogen deposition and this occurs only in the myometrium, while progesterone exhibits no effect. In this study intact as well as progesterone treated rats were utilized. With the development of deciduoma, the glycogen content of whole uterus increased from 68 to 125 mg/100g Wet Weight (W.W.). There was no change in myometrial glycogen, 74 mg/100g W.W. with no deciduoma and 73 mg/100g W.W. in decidual myometrium. Endometrial glycogen content of decidual tissue was 221 mg/100g W.W. Since myometrial glycogen was constant, the increases observed in the decidual tissue of whole uteri must be due to either an increase in the amount of endometrium and/or an increase in the concentration of glycogen in the endometrium. As the deciduoma developed the proportion of endometrium increased from 9% in the uninjured horn to 34% in the injured horn. Thus, an increase in the amount of endometrium contributes to the increase in the glycogen concentration. These results demonstrate that progesterone is responsible for the glycogen increase by stimulating the growth of endometrium, a glycogen-rich tissue. Since no endometrial tissue could be obtained from horns without decidual development, it was not possible to determine whether progesterone had any effect on glycogen deposition. (AH h5-8)

e. Uterine Histamine During Growth of Decidual Tissue.

Histamine, a constituent of almost all animal tissues, has recently been suggested as having a role in the progesterone controlled process of decidual formation. The level of histamine was, therefore, followed during the development of deciduoma, the artificial maternal placenta in the rat. In the process of inducing deciduoma, a stimulus acting upon a uterus in the proper hormonal state causes decidual tissue growth. A wide variety of stimuli, mechanical, electrical and chemical, are effective in acting as the inducing agent. A factor common to all of these inducing agents is tissue damage and histamine has long been known to be a substance associated with tissue injury. While its exact physiological role is difficult to assess, it seems clear that histamine is liberated at times of injury to tissues. The experimental technique utilized in these experiments involved the application of a scratch with a barbed needle to the surface of the endometrium of one uterine horn while the uninjured horn served as a control. As deciduoma developed, the injured horns with deciduoma exhibited a 50% decrease in histamine concentration when compared to the uninjured undeveloped uterine horns. In order to determine whether the scratching procedure or the growth of decidual tissue was responsible for the decrease in histamine concentration, the procedure was

carried out in ovariectomized rats without hormonal influences. Uterine horns which had been subjected to the scratching procedure were found to have a histamine concentration 100% higher than the uninjured horns. The response, therefore, to injury, inflammation and tissue repair was an increase in histamine concentration, while the decidual growth response resulted in a decrease in histamine concentration. (AH h5-8)

3. Endocrine Control of Uterine Defense Mechanisms.

A possible relationship exists between fertility and the uterine defensive mechanisms or their hormonal control. Investigations have been conducted on modes of endocrine control of the uterine defenses and possible species variation in factors related to the defenses.

Hormonal control of the acute inflammatory response was studied in sheep and cattle uteri. Twenty estrous and 20 luteal-phase ewes were inoculated in utero with Escherichia coli; infiltration of the endometrium by polymorphonuclear leukocytes, migration of leukocytes into the uterine lumen and clearance of E. coli from the uterine lumen occurred considerably slower in the luteal-phase ewes. This indicated that in sheep as well as in rabbits the presence of an active corpus luteum delayed the acute inflammatory response in the uterus. The association between leukocytic influx and bactericidal activity was significantly greater in luteal-phase than in estrous ewes, suggesting that extra-leukocytic defensive mechanisms may have been active in estrous ewes.

Thirty heifers were also inoculated in utero with E. coli. Both the leukocytic response and bactericidal activity were slower in luteal-phase heifers than in estrous or ovariectomized ones, indicating that progestin inhibits the acute inflammatory response in uteri of this species also.

Comparisons among cattle, sheep and rabbits showed that leukocytic emigration was considerably slower in ewes than in heifers and rabbits. The physiological basis for this species variation is not known.

In all 3 species studied--rabbits, sheep and cattle--ovarian hormones influenced the uterine defenses primarily through an effect on the intensity of leukocytic emigration. This suggested an effect of the hormones on the vascular response to inflammatory stimuli. Heparin was given intravenously to rabbits at frequent intervals during acute inflammatory responses in the uterus. This anticoagulant did not delay leukocytic emigration or decrease the difference in leukocytic response between estrous and pseudopregnant rabbits. These results failed to suggest that intravenous fibrin formation was a factor in leukocytic diapedesis or that hormonal control of the leukocytic response was effected through such a mechanism.

Vascular permeability was also investigated as a possible means of endocrine control of the uterine defenses. Permeability of vascular endothelium was measured by the intensity of staining of extra-vascular uterine tissues after the intravenous injection of trypan blue dye. In uninoculated rabbits, estrogen maintained uterine vascular permeability at a high level; progestin maintained it at a relatively low level, but slightly higher than in ovariectomized rabbits. After experimental uterine inoculation, vascular permeability increased in uteri of estrous and ovariectomized rabbits. Progestin prevented this increase in pseudopregnant rabbits.

A highly significant relationship was found between leukocytic emigration and uterine vascular permeability during the acute inflammatory response. Both vascular permeability and intensity of leukocytic emigration were greatest in estrous rabbits, intermediate in ovariectomized rabbits and least in pseudopregnant ones. These relationships suggest that ovarian hormones control the uterine defense mechanisms in large part by controlling uterine vascular permeability. The most marked effect was exerted by progestin, which almost completely prevented the vascular response to inflammation. This effect of progestin is likely related to its functions in the maintenance of pregnancy.

Glucocorticoids have been reported to inhibit the ability of the vascular system to respond to vasoactive substances and to inhibit the early leukocytic response to skin infections. The effect of such hormones was investigated in experimentally-infected uteri of estrogen-influenced rabbits. Neither cortisone nor 9-fluoroprednisolone inhibited the leukocytic response or bactericidal activity. These glucocorticoids also had little effect on uterine vascular permeability. However, the injected hormones exerted a marked systemic effect; the normal increase in skin vascular permeability in response to intradermal injection of histamine or cell-free inflammatory exudates was almost completely inhibited. These results suggest that glucocorticoids have little effect in the estrogen-influenced uterus. (AH h5-8)

4. Uterine Defense Mechanisms Against Sperm.

Earlier work has shown that bull sperm are disposed of faster in estrual rabbits than are rabbit sperm. The present studies were undertaken in an attempt to clarify this difference and also to gain more insight into the uterine defense mechanisms. Dead bull sperm were removed more rapidly than live bull sperm in both estrual and luteal rabbits with the estrual rabbits disposing of both live and dead sperm more rapidly than the luteal. With dead and live rabbit sperm, no differences in rate of disposal were observed. The luteal rabbit disposed of both live and dead rabbit sperm quicker than the

estruual animal. Leukocyte numbers did not vary significantly in any of the groups studied. The ability of uterine cell-free exudates to remove sperm was determined. When sperm were suspended in exudates from estrual rabbits previously inoculated with sperm, bull sperm again were disposed of more rapidly than rabbit sperm. Prior inoculations with rabbit sperm produced more active exudates. Leukocyte numbers were not significantly affected by exudate type. (AH h5-6, cooperative with the University of Wisconsin)

5. Effect of Sperm Antibodies or Red Cell Antigens on Reproduction.

Previous work had shown that antibodies coming into direct contact with sperm can affect both fertilization success and embryo survival. These factors were investigated by inseminating 6 heifers with bull semen diluted with antiserum from a heifer immunized against the sperm of the bull. Five heifers returned to heat 21 days after breeding while the sixth had a degenerating embryo 42 days post breeding. Four other heifers were bred with semen diluted with either the "normal" serum of the heifer (obtained before immunization) or a modified Krebs solution. Normal appearing embryos were found in these heifers. A similar experiment in which 6 heifers were bred with bull semen diluted with antiserum from a rabbit immunized against the bull sperm showed similar results, all 6 returning to heat 19-29 days post breeding. When bred with "normal" rabbit serum, fertilized ovas were recovered. When the semen diluted with rabbit anti-bull sperm serum was treated with the sperm cells or the red blood cells (rbc) of the bull, absorption of the antiserum occurred with the sperm cells as evidenced by fertilized ova after use of the absorbed semen. The rbc were ineffectual in causing absorption of the antisperm serum and no fertilization occurred. Additional experiments demonstrated that rbc antiserum did not affect the capacity of semen to fertilize ova in cattle.

Similar results were obtained in rabbits, fertilized ova being recovered from rabbits bred with semen diluted with "normal" serum, sperm-absorbed antiserum and anti-rbc sera. Diluting the semen with antisperm serum or rbc absorbed antisperm serum prevented fertilization in all rabbits bred with these diluents.

The evidence from both the heifer and the rabbit work indicates that an antifertility factor exists in antisperm sera and not in normal sera. This factor prevents fertilization of ova when these sera are mixed with semen prior to insemination. The work also indicates a lack of cross reactivity between the antigens and antisera of sperm and red blood cells since (1) the antifertility effect can be removed from the antisperm sera by absorption with the sperm and not with the rbc's and (2) antisera against rbc's do not affect the ability of sperm to fertilize ova.

Studies were also undertaken at Beltsville to ascertain whether the fertilized ovum and the young embryo can be affected by bovine anti-sera against sperm and red blood cells (rbc) of rabbits. Ninety-five female rabbits have been studied to ascertain the effect of antisperm antibodies on development of fertilized ova. Ova were transferred from one female to another in normal serum (NS) or immune serum (IS). The NS was obtained from a heifer before she was given any injections. The IS was obtained from her following several injections of rabbit semen. The fertilized ova were treated directly with the IS to determine if the antibodies could exert their effect when used in this manner as compared to treating the sperm directly. Also, since considerable variability was noted among the females in previous work where sperm was treated, the NS and IS were tested within females. Ova treated with NS were transferred into one uterine horn and ova treated with IS into the other horn of the same female. Donor rabbits were killed 24 to 30 hours after breeding and their oviducts flushed with the appropriate serum. The ova in serum were then incubated at 37° C. until being transplanted into the oviduct of recipients. Thirty recipients were killed late in gestation to determine survival. Of 136 fertilized ova transplanted in NS, 31 (22.8%) survived as live fetuses while 37 of 127 ova (29.1%) transplanted in IS survived. Thus it appears that the antibodies did not affect survival. There was a positive relationship between the length of time the ova were incubated and the percent survival in both treatment groups. Eleven recipients received ova less than one hour from the time of the death of the donor. In these, 26 of 50 NS ova survived (52%) compared with 25 of 39 IS ova (64%). In studies at Wisconsin with the anti-rbc serum, 49% of the treated ova developed compared to 62% of the normal serum. When antisperm serum was injected into the uterine lumen containing 9-day embryos, only 14% survived to 28 days while 50% survived with normal serum injections. Forty-six percent and 30% of the embryos continued to develop after anti-rbc serum or normal serum injections. The similar results obtained at Beltsville and Wisconsin form the basis of a joint publication in press. (AH gl-7 and AH h5-6, cooperative with the University of Wisconsin)

6. Composition of Mammary Gland Tissue.

The composition of mammary gland tissue and changes during lactation, pregnancy, various endocrine states or in abnormal or disease conditions is not known. There has been little previous work in this area and studies were initiated on sheep mammary gland tissue to determine the normal composition in estrous and luteal sheep and in ovariectomized ewes. The changes occurring after experimental inoculation with bacteria were also determined. (AH h5-1)

a. Chemical Composition.

Initial studies were conducted with nonlactating and lactating sheep. The experimental induction of mastitis was undertaken using an exogenous source of bacterial infection, E. coli. Chemical changes in the mammary glands during the course of inflammation in differing hormonal conditions were followed since previous studies on uterine infection have indicated a difference in defense during either estrous or luteal states. Intramammary inoculations with E. coli were made on one-half of the udder while the other half served as a control. The fat content of mammary gland tissue is high and must be determined in order to express the analytical results in terms of concentrations per unit of fat-free tissue. Unless this is done it is impossible to correlate values from different animals or even different samples from the same mammary gland. When results were expressed in terms of fat-free tissue, there was a great uniformity with respect to water content and to the concentration of the inorganic and organic constituents in replicate samples.

Two and one-half to four hours after the experimental induction of mastitis by bacterial inoculation the treated udder half showed a great increase in size, being 2 times the weight and volume of the control half. This inflammatory response resulted in a dilution of the adipose tissue from about 20% of the total weight in control to about 10% in mastitic glands. Examination of the chemical composition of the mammary gland (water, fat, Na, K, Cl, glycogen, and histamine) during mastitis infection revealed changes in several of the constituents. The water content increased markedly, from about 81% to 87%. The response was somewhat greater in glands under estrous control than in glands from animals in the luteal phase of the estrous cycle. Na and Cl showed a large increase and K a decrease, indicating that the fluid increase probably occurs primarily in the extracellular compartment and is undoubtedly an inflammatory edema. A difference in the change in K content was noted between estrous and luteal glands, suggesting that the estrous gland response involved cellular elements to a greater extent than the luteal response. Whether this was due to mammary tissue cellular elements or to defense cellular elements such as leukocytes, has not yet been determined. Estimates of cell numbers and sizes during mastitis by means of DNA and RNA determinations and histological examination will disclose to what extent cell growth, hypertrophy and hyperplasia are involved in the inflammatory tissue changes. Histamine concentration of the inoculated glands decreased, indicating a mobilization and liberation of this substance which is involved in injury and damage in tissues. The most dramatic changes were observed in glycogen concentration between control and infected glands. Glycogen content increased 3 to 4 fold in the inoculated glands, with the estrous glands showing a larger increase. The results of these preliminary experiments indicate a correlation between the glycogen response and leukocytic invasion. Further work is in progress

to characterize this difference in the defense mechanism in mastitis produced by differing hormonal conditions.

b. Histopathology of Experimental Mastitis in the Ewe.

Mammary gland growth and development is controlled largely by ovarian hormones. An inhibitory effect by progesterone on mammary gland defenses during the initial phases of the inflammatory response might have a marked effect on the severity of mastitis and on the proportion of bacterial challenges to the mammary gland which result in clinical mastitis.

An investigation was conducted to determine the effect of ovarian status on the acute inflammatory response of the mammary gland. Non-lactating ewes in the breeding season were used as experimental animals; it was considered likely that an effect of ovarian hormones on mammary gland defenses could be detected in such animals. Mammary glands of paired estrous and luteal-phase ewes were inoculated with Escherichia coli and glands of estrous, luteal-phase and ovariectomized ewes were inoculated with Staphylococcus aureus.

Inflammation developed rapidly, with severe edema and lymphatic dilatation occurring within 2 hours. By this time the weight of inoculated glands had increased up to 4 times that of uninoculated glands. The leukocytic response occurred rapidly. By 3 to 4 hours the glands were heavily infiltrated by polymorphonuclear leukocytes; interstitial tissue was infiltrated diffusely and most ducts were filled with leukocytes. Microscopic examination and culture of gland cistern and ductular fluids indicated that bacteria were cleared rapidly from the gland as the inflammatory response developed. Phagocytosis by macrophages and microphages occurred widely in the inoculated glands, suggesting that neutrophilic leukocytes were major defensive agents against the introduced bacteria.

There were no consistent differences between estrous and luteal-phase ewes in the rate of development of the inflammatory response, thus indicating that progesterone probably had little if any effect on development of the acute inflammatory response in the mammary gland. The intensity of the initial leukocytic response was somewhat greater in estrous and luteal-phase ewes than in ovariectomized ones, indicating that ovarian hormones promote conditions in the mammary gland favorable to an intense inflammatory response.

Infiltration of the supramammary lymph nodes by neutrophilic leukocytes progressed rapidly. This neutrophilic infiltration indicated that products of inflammation, probably including bacterial toxins and small numbers of bacteria, entered the lymphatic system and reach the supramammary lymph nodes rapidly. This may be associated with the

finding by others of a rapid antibody production following infusion of antigen into the mammary gland. The supramammary lymph nodes of these ewes generally contained large numbers of plasma cells.

C. Nutrition

1. Metabolic Role of B₁₂

Previous work at Beltsville has shown that vitamin B₁₂ functioned in the metabolic disposal of the carbon moieties of four amino acids comprising the casein protein, namely: serine, valine, isoleucine and threonine. Additional studies implicated propionic acid formed in the catabolism of valine, isoleucine and probably threonine. Further investigations demonstrated that in the dominant pathway of catabolism of propionic acid in animals, in which this fatty acid is carboxylated to methylmalonic acid, B₁₂ is involved in the isomerization of the latter acid to succinic acid which is then metabolized in the citric acid cycle.

Propionic acid and also certain branched-chain and odd-carbon straight chain fatty acids which give rise to propionic acid in animal metabolism are normally formed in the rumen by microbial action on the feed and serve as an important source of energy for the host animal. Experiments with rats were carried out to study the relation of vitamin B₁₂ to the metabolism of these and other rumen acids. Various volatile fatty acids and related acids were fed to B₁₂-deficient and B₁₂-supplemented rats in a basal ration containing a normal level of protein, and the effects on growth and survival were followed.

Formic acid, fed as formate, brought about a significant growth depression in B₁₂-deficient animals and caused some deaths. With a supplement of the vitamin, no deaths occurred and growth remained normal. These results indicate that vitamin B₁₂ is concerned in the animal metabolism of formate.

In the absence of vitamin B₁₂, the even-carbon straight-chain rumen fatty acids, acetic and butyric, brought about no further lowering of the growth rate and caused no deaths among the animals. In contrast, propionic acid and the odd-carbon straight-chain n-valeric acid, which produces propionic acid in the course of its degradation in the animal body, caused significant depression in growth and led to death among the animals. Supplementing the rations containing the latter two acids with B₁₂ prevented deaths and allowed normal growth.

The branched chain acids--isobutyric and 2-methylbutyric--produced significant lowering of the growth rate in the absence of B₁₂ and deaths occurred among the animals fed the latter acid. When a supplement of B₁₂ was given, no deaths occurred and growth was not significantly different from normal with either acid. On the other hand,

the branched-chain isovaleric acid caused no further growth depression in B₁₂ deficiency. These results thus show that isobutyric acid and 2-methylbutyric acid, which are present in and are absorbed from the rumen, require B₁₂ for their catabolism.

Lactic acid, although not ordinarily but under some conditions present in the rumen, and pyruvic acid caused no further growth depression in the absence of B₁₂. Thus, cobalt in the form of B₁₂ is undoubtedly essential for the catabolism of certain rumen acids. (AH h4-3)

2. Synthesis of B₁₂ in the Rumen.

Biosynthesis by the rumen flora in the presence of cobalt is the sole or predominant source of B₁₂ for the ruminant. B₁₂ analogues, which may be important in normal maintenance of the flora themselves, are likewise thus synthesized. A survey has been conducted of the various functional microorganisms present in the rumen to determine which strains and species among them synthesize B₁₂ or B₁₂ analogues. The tests were made on pure cultures of a number of species of functional rumen organisms of the cow. All of these cultures were grown in essentially the same medium, which included 20% clarified rumen fluid, in an attempt to approximate conditions prevailing in the rumen. The assay method used for screening the organisms was the E. coli mutant 113-3 plate test.

Forty-eight strains, representing twenty-one different species, of rumen organisms were tested. These included representatives of most of the important genera isolated from the rumen of the cow. Only eight of the strains, representing four different species, synthesized an appreciable amount of B₁₂ or its analogues.

The active samples were also assayed by the E. coli tube test and with Ochromonas malhamensis. The latter test reflects true animal activity, while a comparison between the E. coli plate and tube tests gives some indication of the particular analogues being synthesized. The assays with Ochromonas indicated that the pure cultures in most cases did not produce as high a percentage of B₁₂ per se compared to the analogues as has been found in rumen fluid. While clarified rumen fluid was added to the culture medium to simulate as nearly as possible the conditions prevailing in the rumen, it is obvious that the conditions were not exactly the same where the various species of microorganisms grow symbiotically. However, it represents probably about as close an approach as can be made under pure culture conditions.

Studies to determine more exactly the particular B₁₂ analogues present in these cultures have been initiated, using the techniques of ionophoresis and chromatography combined with bioautography. Such tests have now been carried out on the Selenomonas strains. Two different analogues were observed, with almost all of these cultures

but their relative intensities varied from culture to culture. Thus, certain definite strains of rumen bacteria synthesize B₁₂ in the rumen. (AH h4-4)

3. Unidentified Nutrients.

Investigations on the still unidentified nutrients occurring in foods and feeds have been continued. For these studies, rats were used whose requirements for dietary essentials were increased by feeding them thyroprotein and thus making them hyperthyroid. The purified control ration fed to these rats contained all known nutrients in amounts required by the hyperthyroid rat. In addition, it contained cholesterol, which was found to stimulate the growth of such rats, and sulfasuxidine, which was found of value under test conditions in increasing the magnitude of the differences in weight gain between unsupplemented rats and those fed sources of unidentified nutrients. Differences in growth of 25 to 50 grams per rat in three weeks have been observed.

Experiments were carried out to throw light on the mode of action of sulfasuxidine in these tests. Two other sulfa drugs were tried for purposes of comparison--sulfathiazole and sulfathalidine. Sulfathiazole is absorbed from the digestive tract so rapidly that it seems to have little effect on the flora of the tract. Sulfathalidine, on the other hand, is so little absorbed that its action seems to be confined almost if not entirely to the intestinal flora. Sulfasuxidine is likewise absorbed only to a limited extent but seems to be more soluble than sulfathalidine. In these tests, the results obtained with sulfathiazole resembled those obtained with sulfasuxidine more nearly than those obtained with sulfathalidine. Thus, these experiments would seem to cast doubt upon the theory that the action of sulfasuxidine in these tests may be to prevent synthesis of some unidentified nutrient in the intestinal tract and suggest, rather, some systemic effect.

Storage of unidentified nutrients in the livers of rats and depletion under conditions where demand is increased by the feeding of thyroactive rations has been studied. Livers were collected from rats fed a thyroactive ration and compared in potency with those taken from rats fed a stock ration. As measured by the growth response of hyperthyroid test rats, the livers obtained from stock rats were significantly more potent in unidentified nutrients than those secured from hyperthyroid rats. These results indicate that the stress imposed upon rats by feeding them thyroactive rations tend to deplete their livers of their natural stores of these unidentified growth factors and fit in with the concept of them as "vitamin-like" in nature. Thus, the evidence continues to mount that there are still some unidentified vitamin factors despite the fact that evidence for their presence and their separation is proving to be difficult.

Tests of several lots of fishmeal for relative activity for unidentified nutrients indicated that they varied considerably in potency. The reasons for this variation are not clear, but they may be related to time and conditions of storage after processing.

Attempts at fractionating the active material from fishmeal have been made. Extraction with organic solvents (diethyl ether followed by acetone and the absolute alcohol) yielded evidence suggesting that some of the active material might be associated with a lipoprotein fraction. When the fishmeal was first extracted with alcohol so as to denature the protein, these organic solvents were no longer able to remove active material. The fishmeal residue still contained all or almost all the activity as well as 83% of the solids of the original fishmeal. Further purification was accomplished by hydrolysis with H_2SO_4 treatment with alcohol, neutralization, extraction with acetone and ether and absorption on Norit. The solids on the Norit which appeared to contain much of the activity consisted of about 0.6% of the weight of the original fishmeal and represented an intake of about ten milligrams per test rat per day. In other experiments, treatment with various concentrations of alcohol, acetone or an alkaline 70% alcohol solution failed to remove the activity from Norit. (AH h4 1)

4. Basic Research on Ruminant Metabolism.

Dairy goats have been used in basic research on ruminant metabolism in cooperation with the University of Maryland. Studies on the metabolism of acetate and palmitate in the ruminant liver were carried out with goat livers in vitro in an artificial heart lung perfusion system using acetate $1\text{ }C^{14}$ and palmitate $1\text{ }C^{14}$. These studies confirmed the finding that large amounts of acetate pass through the liver without being metabolized and also demonstrated the utilization of acetate for liver oxidations and synthesis of various lipids. Palmitate has been shown to be oxidized by the liver and a rapid exchange between liver and blood long chain fatty acids has been demonstrated. Several lactating goats have been fed radioactive S^{35} to label the milk proteins and sulfolipids. This labeled milk has thus been used in studies on milk chemistry. (AH b4 3)

5. The Metabolism of Zinc by Rabbits.

Research was undertaken at Madrid, Spain, under PL 480 to study the metabolism and excretion of zinc in animals. Zinc 65 chloride was quickly absorbed after injection into the peritoneum of rabbits. Organs which take up and lose zinc quite rapidly include the liver, spleen, pancreas, reproductive organs and bowels. Organs like the brain and muscle reach the highest level of concentration after a relatively long time and they lose the zinc quite slowly also. Accumulation of zinc takes place principally in the bones. Excretion is

mainly through the feces. The excretion through the urine in male rabbits is practically nil. (E-25-AH-4)

C. Rumen Function

This work primarily relates to studies on rumen microbiology and metabolism in cattle. It is largely basic in nature but is also pertinent to work on the nutritional efficiency of cattle. (AH h2-3)

1. Amino Acid Catabolizing Bacteria.

Studies on the bacteria responsible for the catabolism of amino acids to NH_3 and volatile fatty acids in the rumen indicated that Bacteroides ruminicola was important. In addition to catabolizing some other amino acids it catabolizes branched-chain amino acids such as leucine with the production of branched-chain volatile acids such as isovaleric acid and NH_3 required for growth of many other rumen bacteria including cellulose digesters. Thus, B. ruminicola is an important component in microbial interactions affecting protein synthesis and breakdown and cellulose digestion in the rumen.

2. Growth Requirements of Rumen Bacteria.

Studies on many strains of previously identified bacteria known to be functioning in the rumen of cattle fed a wide variety of rations and on strains freshly isolated from the rumen revealed that most strains of most species can now be grown in defined media or in media in which vitamin-free casein hydrolysate is the only ingredient not defined (86% of strains in one study). Relatively few of these bacteria require higher fatty acids, nucleic acid derivatives of many other growth factors not included in the media. Almost all of the bacteria require one or more B-vitamins.

Nitrogen sources for growth are usually very simple in that NH_3 serves this purpose in most strains (80% in one study) of most species. Some of the latter are versatile in that they can utilize either NH_3 or amino acid mixtures as nitrogen source. However, some species (six species and 26% of total strains in one study) require NH_3 for growth and fixed amounts approximating the amount of protein nitrogen produced even when large amounts of organic nitrogen (amino acids and peptides) are present in the growth medium. These same species and some others which do not require NH_3 , i.e., they can utilize exogenous amino acid nitrogen, utilize very little exogenous amino acid carbon (C^{14}) in protein synthesis. Thus, the rumen contains many organisms that have to synthesize most amino acid constituents of their protein from NH_3 and exogenous nonamino acid carbon. This suggests that the ability to efficiently utilize amino acids is of little survival value in the microhabitat of many rumen bacteria perhaps because little amino acid is available to them. No other heterotrophic organisms

are known which synthesize most of their cellular amino acids when exogenous amino acids are available. A small proportion of rumen bacteria require amino acids for growth (6% in one study) and about half of the species efficiently utilize exogenous amino acid carbon.

It was found that one or more of the volatile fatty acids, isovalerate, isobutyrate, 2-methylbutyrate and n-valerate are required for growth of many strains of rumen bacteria (20% in one study) and that these include several species other than the cellulolytic species previously reported.

3. The Function of Isovalerate in Rumen Bacteria.

Studies utilizing isovalerate-1 and 3 C¹⁴ and the cellulolytic bacterium Ruminococcus flavefaciens showed that the intact carbon skeleton was utilized for synthesis of leucine of cellular protein. Further studies showed that the carboxyl carbon of leucine synthesized from isovalerate was derived from CO₂, i.e., a CO₂-fixation reaction. This mechanism of leucine synthesis was not previously known. C¹⁴ studies with whole rumen contents indicate that this mechanism is important in leucine synthesis in the rumen and that a similar mechanism for synthesis of valine from isobutyrate and CO₂ is also functional.

It was also shown that isovalerate and isobutyrate serve as sources of the branched-chain moiety in biosynthesis of higher branched-chain fatty acids and aldehydes in pure cultures of cellulolytic bacteria. Much of the higher fatty acid and aldehydes was found in phospholipids. This is the first report of these higher aldehydes in bacteria and indicates that plasmalogens are of significance in ruminal bacteria. The functions of these acids and aldehydes in the cell are unknown. Attempts to replace the isovalerate growth requirement of R. flavefaciens with lipids or lipid fractions extracted from R. flavefaciens cells were unsuccessful.

The results suggest that branched-chain volatile acids are required for growth of certain rumen bacteria because of a limited ability or inability to synthesize the isopropyl moiety found in branched-chain amino acids and in lipid and a limited ability to incorporate exogenous amino acids.

4. The Nature and Importance of Rumen Microbial Lipids.

In cooperation with workers of the University of Maryland, branched-chain and odd carbon higher fatty acids and aldehydes similar to those of the cellulolytic bacteria were identified as major components of the bacterial fraction of rumen contents. The quantity and character of those microbial lipids are interpreted as indicating that

significant quantities of ruminant fatty acids including milk fat acids and aldehydes originate from rumen microbial synthesis of long chain acids and aldehydes from volatile fatty acids.

5. Hemin Metabolism in the Rumen.

In studies on the nutrition of Bacteroides ruminicola, an important rumen bacterium, it was found that hemin replaced the "rumen fluid" factor requirement of subspecies ruminicola which usually accounts for about 80% of strains of B. ruminicola isolated from rumens of cattle. Studies indicated that this organism utilizes a wider range of tetrapyrroles than any heme-requiring organism previously studied but that many compounds which replace heme requirements in some microorganisms are inactive. Compounds which replaced heme in iron containing medium included catalase, peroxidase and hemoglobin, proto-, hemato-, meso-, and deuteroporphyrin, zinc and manganese protoheme, and uro and coproporphyrinogen. Compounds which would not replace hemin included cytochrome C, bilirubin, chlorophyll, citrate, ethylenediaminetetraacetic acid, ferrichrome, coprogen, terregens factor, delta-aminolevulinic acid, porphobilinogen, coproporphyrin, uroporphyrin and copper protoheme.

Heme independent B. ruminicola subsp. brevis excretes porphyrin, probably mainly coproporphyrinogen, into the medium during growth and washed cells produce porphobilinogen and porphyrin from delta-aminolevulinic acid. Subspecies ruminicola does not have these abilities. The results indicate that B. ruminicola synthesizes porphyrins via mechanisms similar to those found in other organisms and subspecies ruminicola lacks one or more of the enzymes in the pathway between succinate plus glycine and uroporphyrinogen.

Studies on cellular heme compounds of both subspecies indicated that they contained a cytochrome similar to cytochrome o but of unknown function and a cytochrome of the b type involved in an electron transport system, also containing flavoprotein, by which DPNH generated by glycolysis causes the reduction of fumarate to succinate, the major fermentation product of this organism and an important intermediate in propionate production in the rumen. No other hemoproteins were detected and all of the heme extracted from cells appeared to be protoheme. This is the first indication that cytochromes are involved in energy metabolism in the rumen or in any strictly anaerobic, carbohydrate fermenting organism. Also, the studies seem to give at least one reason for the known iron requirement for protein synthesis, i.e., bacteria growth, in the rumen. Since the heme independent subspecies has the same functions as the heme requiring subspecies and produces porphyrin utilized by the latter, it is doubtful that absence of porphyrins in ruminant rations would reduce the efficiency of the rumen fermentation. This work was done in cooperation with D. C. White and S. Granick of the Rockefeller Institute, New York.

By following oxidation and reduction of the cytochrome b and flavo-protein in cells of Bacteroides ruminicola, evidence was obtained that succinate was produced from carbohydrate via CO₂ fixation to pyruvate one related compound, produced by glycolysis, and reduction of the resulting oxalacetate to succinate via malate and fumarate.

6. An Improved Culture Medium for Rumen Bacteria.

A new rumen fluid medium has been developed for the nonselective culture, counting and isolation of ruminal bacteria. This medium supports the growth of about double the colonies of the old medium, colonies are easier to count and many more can be counted per tube. That counts were doubled but similar proportions of species were isolated as compared to the old medium indicates that some of the discrepancy between culture counts and direct microscopic counts of rumen contents is due to failure of some cells of species cultured to grow in artificial media rather than failure to grow some species.

7. Affect of Animal Management on Rumen Bacterial Counts.

Using the new medium, it was shown that total b viable counts of rumen bacteria vary significantly in relation to the ration consumed, time of sampling relative to time of feeding and watering, the number of times a day the animal was fed, the position in the reticulo-rumen samples and in relation to unknown factors. It is evident that these viable counts are an excellent tool for use in obtaining a better understanding of the kinetics of the ruminal fermentation.

8. Digestion of Highly Resistant Cellulose Fibers.

In studies with a visiting scientist from Rowett Research Institute in Scotland, it was shown that strains of cellulolytic bacteria previously isolated and characterized in this laboratory and shown to digest partly degraded cellulose, i.e., finely ground cotton or filter paper, could also digest highly resistant, native cellulose from cotton fibers. Such data adds to an understanding of the function of these bacteria in digesting cellulose and shows that they are truly cellulolytic. (AH h4-3 and is also reported in Area 1, B-2)

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AREA NO. 2 - BEEF CATTLE - BREEDING

Problem. Expression of each of the productive and carcass traits of beef cattle varies from breed to breed and between animals within each breed. The beef cattle producer is constantly striving to achieve excellence in one or more of these traits. Frequently his failure to choose the best animals for breeding stock or the most effective mating program results in less than maximum progress. Often the beef cattle producer does not know how to identify, evaluate and utilize the existing variability to achieve his aim. Research information is needed on heritability of economic traits in beef cattle, genetic and phenotypic correlation between these traits, effectiveness of various selection and breeding programs, and assessment of traits most useful in beef cattle improvement.

USDA PROGRAM AND RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

The beef cattle breeding research in the United States has developed as a coordinated program of the USDA and the State experiment stations. It is a continuing program of both applied and basic research carried on by geneticists, animal physiologists, and animal husbandmen. Early efforts in the improvement of beef cattle through performance testing were made by the USDA at Miles City, Montana, and Beltsville, Maryland. With the advent of regional research, efforts by the State stations were greatly increased and the individual programs were coordinated through regional research projects in three of the important beef cattle producing regions. This joint activity has been and remains characteristic of beef cattle breeding research, and the resulting program is an integrated effort combining to the best advantage the resources of the State experiment stations and the USDA.

The regional project in the South is S-10, Improvement of Beef Cattle for the Southern Region through Breeding Methods. Much of this region is subtropical in climate and in many cases cattle used in other areas are poorly adapted. Environmental conditions adversely affecting survival, reproductive regularity and growth are encountered. Research includes projects at 13 State stations and at the USDA stations at Jeanerette, Louisiana; Front Royal, Virginia; and Brooksville, Florida.

In the Western region the beef industry is largely geared to range conditions with many cattle shipped to areas of abundant grain supply for fattening. Ability to make maximum use of forage available on the range is an important consideration. These problems are studied through regional project W-1, The Improvement of Beef Cattle through the Application of Breeding Methods. Research includes projects at 12 State stations and at the USDA station at Miles City, Montana.

Similarly, NC-1, Improvement of Beef Cattle through Breeding Methods, is geared to problems of the beef industry in the North Central region where beef is produced on farms with pastures of high productivity and ample grain supplies for feedlot finishing. Research includes projects at 12 State stations and at the USDA stations at Fort Robinson, Nebraska, and Fort Reno, Oklahoma.

A coordinator for each of these regional projects is provided by the USDA. A number of the States in these three regions have other research in beef cattle breeding which is not formally contributing to the regional program but is closely associated and coordinated with the overall effort. Beef cattle breeding research of limited scope is also conducted at four State stations not in regions with regional projects, and at Beltsville, Maryland.

The Federal scientific effort devoted to research in this area totals 17.4 professional man-years. Of this number, 1.3 are devoted to performance testing, 4.7 to genetics and interrelations of performance traits, 1.0 to genetic environmental interactions, 7.7 to selection and systems of breeding, and 2.7 to program leadership.

State experiment stations in 1961 reported a total of 62.2 professional man-years divided as follows: performance testing 8.4; genetics and interrelationships of performance traits 18.0; and selection and systems of breeding 35.8.

In industry at least one meat packing company has a developmental and demonstrational project on beef cattle improvement. Two breed registry associations have conducted studies on dwarfism. A State cattle feeders' group has assisted in coordinating ranchers, feeders, and packers in providing cattle and services for a study on crossbreeding. These efforts amount to approximately 4 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Because of the longtime nature of most beef cattle breeding projects it is difficult or impossible to report progress on an annual basis in a completely clear-cut manner. In the material which follows an attempt has been made to discuss those items on which data analysis or summaries during the reporting period have brought out specific information. In some cases it is new. In other cases it supplements previous results.

A. Genetics and Interrelationships of Performance Traits

1. Genetic Defects.

Research on hereditary dwarfism was continued during the year on a reduced scale. Further research with radiographs of the lumbar vertebrae show the same accuracy of this technique as reported in

previous years (approximately 80%). In general, a higher percentage of bull calves than heifer calves are predicted as "carriers" on the basis of this technique. (AH dl-31)

Hematological studies in regard to exploring possible techniques for identifying carriers of the dwarf gene have been continued during the year. No new techniques that show promise have evolved from these investigations. (AH dl-31)

At California test matings of Dexter to brachycephalic, dolichocephalic, and comprest mutants produced distinct types discontinuous in size. "Bulldog" calves sired by Dexter and aborted at seven months showed complete fusion of the spheno-occipital synchondrosis. (AH dl-39)

The Florida Station has concluded that the compact animal, known in Florida as the "guinea" is the heterozygote for the Dexter bulldog gene. They have also indicated that there is some genetic or physiological relationship between the guinea and the snorter dwarf since crossing them has resulted in a Dexter bulldog and numerous resorptions. Their work has also indicated that the Brahman carries the snorter gene and the midget is probably the heterozygote for the snorter dwarf gene. The Florida work indicates that mixed breeding may modify the expression of dwarfism. Cooperative work with the medical school at that station on acid mucopolysaccharidosis in dwarfs continues. Carbazole and naphthoresorcinal tests for hexuronic acids in the urine will be made on carrier and clean calves. The Texas station is continuing their work on the relationship of amino acid metabolism to mucopolysaccharide accumulation in dwarf carrier and clean animals. (AH dl-9, dl-22, dl-34)

Interpretation on genetic relationships of different types of dwarfism continues to differ with California workers interpreting genetic and anatomical data from specific matings as lending support to the theory that achondroplasia is a complex of a number of components genetically related. On the other hand, results of additional matings at Ft. Reno, Okla., continue to indicate that the "snorter" dwarf, "long-headed" dwarf and the "comprest" condition are each due to different alleles with the "snorter" and "long-headed" dwarf condition being inherited as simple autosomal recessives and the "comprest" condition inherited as an incomplete dominant. (AH dl-39, dl-31)

Results summarized during the year show a "spastic" lethal in Hereford cattle to be inherited as a simple autosomal recessive. "Malocclusion," another achondroplastic condition was reported in Hereford cattle. It is also inherited as a simple autosomal recessive. (AH dl-12)

Previous work had shown hydrocephalus to be inherited as a simple recessive. Some workers now feel that this condition cannot be completely separated from achondroplasia. (AH dl-39)

A sire in one of the Oregon lines that had 7 hydrocephalic calves out of 9 born was subsequently test-mated to 20 females within this same line. These females were divided into groups of 10. The first group was fed iodized salt and the second group got no iodized salt. The first group had one hydrocephalic calf. While the evidence so far is not conclusive, the Oregon workers feel that we cannot yet rule out the possibility that hydrocephalus is caused by a genetic-nutritional interaction involving lack of iodine. Quite possibly there are different types of hydrocephalus. (AH d1-19)

New Mexico has analyzed data and is preparing a manuscript on vaginal prolapse. The tendency of some bulls to sire daughters with a high incidence of vaginal prolapse suggested the trait may be heritable. It was noted that incidence of prolapse differed between the two herds, one run under intensive farm conditions and the other on open range, with the incidence much higher under the farm environment. (AH d1-18)

2. Performance Traits.

Heritability estimates for growth rate from birth to weaning continue to indicate that there are genetic differences between sires. However, information from 1448 calves from 29 Angus, 39 Hereford and 16 Shorthorn sire groups from the Mississippi station indicates that the heritability estimates for growth rate from birth to weaning might be lower than has been previously indicated. When analyzed within breed, these data indicated that heritability for growth rate for Angus was 0.10, Herefords was 0.23 and Shorthorns was 0.12. Heritability estimates of weaning weight were 0.17 for Angus, 0.45 for Hereford and 0.15 for Shorthorn. (AH d1-28)

Data on the progeny of high and low gaining sires from two different stations indicate that the average of the progeny of the two groups for growth rate will be ranked the same way as the sires themselves.

Results continue to show high heritability estimates for carcass weight, rib-eye area and tenderness, while the estimates of heritability of percent untrimmed round, percent major wholesale cuts (untrimmed), percent fat, percent lean of the 9-10-11 rib cut and fat thickness at the 12th rib were somewhat lower. (AH d1-12, d1-38 (c))

Different analytical procedures were compared for obtaining paternal half-sib estimates of heritability. This study demonstrated the necessity for making logical decisions in considering a variable fixed or random in that analytical procedure used appreciably affects the estimate obtained.

In a cooperative study at St. Paul, Minn., attempts are being made to evaluate relationships of dairy and beef characters by improving milk production in a herd of Milking Shorthorns and observe trends in beef

characters of steers produced in the herd as milk production increases. To date average milk production has been only about half (8,000 lbs. vs. 16,000 lbs.) and calves have grown more slowly as compared to a Holstein herd maintained under the same conditions. (AH dl-27)

3. Genetic-Environment Interactions.

As detailed below, quite a few bits of data strongly suggest the reality of genetic-environmental interaction but do not permit estimates of whether they are important enough to make the development of many strains or breeds each adapted to a particular environment, a necessity for maximum production.

At Beltsville, Md., a trial has been completed in which pairs of identical twins were split and one member fed on a high concentrate ration and the other on a high roughage ration. Pair-ration interactions were statistically significant for rate of gain, efficiency of gain and several carcass traits reflecting fat percentage. (AH dl-32)

A three-year test of four inbred lines crossed to grade cattle has been completed at Oregon. Significant differences in year and year x line of sire were observed. However, performance within the lines was in agreement with the performance of the crossline progenies. As a result of these studies, a four-year diallel breeding program involving three of the above inbred lines has been initiated in an attempt to test combining ability and derive new gene combinations containing the desirable traits exhibited in each of the original lines. (AH dl-19)

Nevada's small animal investigations revealed that rats from lines selected for 70-day weight under a high plane of nutrition were not consistently superior for weight at 70 days to rats from lines selected under a low plane of nutrition. Moreover, a high incidence of sterility was observed in the line selected for size under a high plane of nutrition.

In cattle studies at this station, calves within the line selected for conformation tended to gain at a slower rate and were less efficient than calves from lines in which selection was practiced for rapid gain or efficient feed conversion. Within the two locations where cattle are being studied, calves from rate-of-gain and economy-of-gain lines appeared to be similar in performance. (AH dl-36)

Recently, two studies have been initiated in the Southern Region to try to arrive at estimates of the magnitude of this genetic-environmental interaction. A North Carolina experiment is utilizing four locations within the State and different treatments at each location to evaluate how the progeny of sires react to different conditions. They are

utilizing artificial insemination so that the same sires can be used in different treatments and different locations each year. (AH dl-23)

An interregional study has been initiated using cattle from Miles City, Montana, and Brooksville, Florida. Cattle from Miles City have been transferred to Brooksville. Additional transfers will be made this year so as to evaluate how Miles City, Montana, cattle selected for that area respond to selection in Florida and vice versa. This is the first year for this project.

B. Performance Testing

Attention to improving methods for evaluating performance in beef cattle is continuous in most projects. The most significant overall recent trends are increased attention to (1) carcass evaluation including methods of estimating carcass characteristics from live animals, and (2) evaluation of fertility and the components or factors upon which it depends. Routine evaluations of these traits will make more comprehensive future genetic analyses possible.

Research involving the use of ultrasonics for measuring differences in fat and muscling in live beef cattle is generally encouraging. Correlations between estimates with this equipment in live cattle and measures in the carcass have been 0.6 to 0.8 for fat thickness and rib-eye area. (AH dl-10)

Other studies with other operators have been less promising. At the U. S. Range Livestock Experiment Station, ultrasonic estimates of rib eye and fat depth were made on 52 steers. The partial correlations with live weight held constant were: Ultrasonic rib eye and carcass rib eye, 0.07; ultrasonic fat depth and carcass fat depth, 0.15; and ultrasonic rib eye and fat depth, -.04 (AH dl-2)

Correlations between subjective estimates of fat thickness and rib-eye area in slaughter cattle with measures of these traits in the carcass have averaged approximately 0.4 to 0.5. This was among slaughter cattle of rather uniform weight and condition. Results continue to show that most of the variation in carcass grade can be accounted for by differences in marbling. Cattle involved in these studies ranged from USDA Good to USDA Prime. Studies continue to show a very low correlation (0.1 to 0.2) between thickness of outside fat at 12th rib and marbling score in the USDA Good to USDA Prime grade range. (AH dl-12)

Utah studies show very low correlations between marbling and tenderness. Tenderness has not been related to preslaughter rate of gain. (AH dl-20)

Studies have been initiated involving the use of the Liquid Scintillation Counter for measuring differences in Potassium-40 content of trimmed and untrimmed wholesale cuts. These studies also involve physical

separation of fat, lean, and bone of these cuts, as well as chemical determinations of ether extract and nitrogen.

Studies continue to show variations in fat to be the most important single factor affecting yield of trimmed retail cuts. Studies show only a small amount of variation in distribution of trimmed wholesale cuts. Preliminary results indicate that the yield of trimmed retail cuts from the round, loin, rib and chuck can be predicted rather precisely from a knowledge of fat thickness at 12th rib, rib-eye area, kidney and pelvic fat and carcass weight. (AH dl-12)

The Texas station has derived mathematical equations for estimating the amount of lean in the carcass using carcass weight, percent kidney fat, thickness of fat over the rib-eye and loin-eye area. Equations have also been developed by the Tennessee station using rib fat thickness and carcass weight, as well as other factors. (AH dl-9, dl-22)

Further studies of tritium and N-acetyl 4-aminoantipyrine have shown that they are reasonably accurate for estimating body composition in live cattle. (AH dl-20)

A curvilinear relationship of fat thickness and rib-eye area at 12th rib with carcass weight was found for both heifers and steers.

Up to about 725 pounds carcass weight, heifers had larger rib eyes than steers but the increase in rib-eye area leveled off more rapidly for heifers. For fat thickness the regressions were nearly identical for the two sexes with the heifers being fatter at the 12th rib than steers of the same carcass weight.

While a seasonal plateau was observed in preweaning gains, using average daily gains from birth to weaning to adjust weaning weight for differences in age was found to be almost as accurate as taking cognizance of this plateau in the development of the most appropriate adjustments for weaning weight. (AH dl-12, dl-13)

Selection indexes used to predict net merit for the economical production of beef were compared in theoretical studies. There were (1) weaning weight, post-weaning average daily gain and estimated feed consumption from weaning to 1000 lbs., (2) weaning weight and post-weaning average daily gain and (3) weaning weight alone. Net merit was defined as a function of weaning weight, post-weaning gain and post-weaning feed consumption. Feed consumption to 1000 lbs. was estimated by fitting a curve to individual feeding data. Index (2) was computed to be .73 as effective as (1) and (3) .24 as effective as (1). Considerable progress could be made in the economical production of beef by selecting for weaning weight and post-weaning gain; however, considerable loss in accuracy of identifying superior animals as defined here would be expected when selecting for weaning weight alone. (AH dl-12)

Studies on milk production of beef cattle are being continued at three stations. It appears from these studies that there are breed differences in milk production and that there is a significant relationship between milk production and calf gains. In a study at the Alabama Station, it appears that milk production, per se, is more important than any of the other component parts affecting slaughter grade. Data from this station indicate that heritability of milk production estimated on a within-sire intra-class correlation basis was approximately .33 for Angus and .46 for Herefords. When estimated on a paternal half-sib basis, these estimates were considerably higher. At the Jeanerette station, where the calves were removed from the cow for a 12 to 16 hour period, then weighed, allowed to nurse, and weighed again, the Sindhi and Brangus cows appeared to be highest in milk production. The Angus and Africander-Angus cows were intermediate and the Brahman cows were lowest. There was little difference in milk production of cows nursing straightbred and those nursing crossbred calves. In this study, cows that were five years of age and older consistently gave more milk than three to four year olds. It appears from these studies and other non-contributing projects that milk production in beef cattle is heritable and that progress in increasing milk production could be made by selecting calves with heavier weaning weights. Further work on this aspect will be continued at these and other stations. (AH dl-6, dl-8, dl-29)

Continuing data on creep-feeding in this area indicate that growth rate can be increased from birth to weaning by creep-feeding, depending to a great extent on pasture conditions. In most studies, however, creep-feeding has not been economical in the Southeastern United States. Gain data from the Texas station have indicated that calves averaging 1000 pounds in 365 days or less can be produced if nutritional and management conditions are optimized. The Texas station is also studying feed efficiency. They have indicated that differences in weight, rate of gain and level of feed consumption often make interpretations of feed efficiency data difficult. When daily feed consumption was equalized among calves, they were able to show that average daily gain on test was quite variable, even though initial weight on test was fairly equal. (AH dl-22)

At Wyoming a project has been underway for several years in which semen is collected and frozen from young bulls prior to slaughter. Semen from those with superior carcasses is later used for breeding. Conception rates from semen of bulls slaughtered at 12-14 months has not been good, so the slaughter age is being increased to 16-18 months. (AH dl-25)

Data are continually being collected and analyzed on environmental factors which affect calf weights and gains. Adjustments for sex of calf have recently been estimated at the Alabama station. This study showed that bulls, on the average, were 23 pounds heavier than steers and heifers were 47 pounds lighter than steers. The Mississippi station reports that they found that steers weighed approximately 22 pounds

more at weaning than heifers and that the male calves weighed 4.3 pounds heavier, on the average, at birth than females. A cooperative study by Texas and Virginia revealed that location had a significant influence on performance records of calves from the two States' Beef Cattle Improvement programs. This study was not conclusive, however, in showing whether or not the same growth adjustment factors could be used in the same locations. (AH dl-4, dl-22, dl-28, dl-29)

C. Selection and Systems of Breeding

1. Crossbreeding.

During the year, a summary was completed and a regional bulletin published summarizing all crossbreeding results to date in the southern project. Data on over 6000 cattle in 60 different purebred or crossbred combinations contributing information to one or more phases of the study were included. Conclusions of the study were:

Maternal ability as measured by growth rate of calves from birth to weaning was better in the British-Brahman crossbred dams than the straight Brahman and much better than the average of the British dams. Crosses between British and Brahman types were significantly heavier at birth than the average of the two parental types. Heterosis for birth weight from crosses among British breeds was small and averaged about two percent. With crosses among the British breeds, heterosis for growth rate from birth to about 15 months of age was about four percent. Limited data at one station suggested a slight decrease in growth rate for backcrosses and a slight increase over first crosses for three-breed crosses. First crosses between British and Brahman types showed 11.5 percent heterosis for growth rate from birth to about 15 months of age. Straight British calves grew about seven percent faster than straight Brahman. Backcrosses to the British type were more effective than backcrosses to the Brahman type in keeping growth rate near the level achieved in the first cross. Carcass traits not directly related to growth rate showed little evidence of heterosis in crosses and usually were near the average of their parents.

In a preliminary analysis of data at Fort Robinson, Nebraska, on heterosis effects involving reciprocal crosses among the Angus, Hereford, and Shorthorn breeds, it was found that the crossbreds grew approximately five percent faster than the straight breds by the same sires. The crossbreds had more outside and kidney fat than the straight breds at the same age; however, there was no difference in carcass grade. Rib-eye area was greater in the crosses at the same age. The crossbreds reached puberty at younger ages and lighter weights than the straight breds. (AH dl-12)

There are several comparisons of crossbreeding systems, such as single-crossing, back-crossing, three-breed crossing, rotational crossing and grading up. Limited data indicate that some of the hybrid vigor is lost in a back-crossing program as compared to single crosses when growth rate is considered. This appears to be true also in a continued back-crossing program. (AH dl-3, dl-7)

In contrast to the Fort Robinson data, Louisiana results suggest that age of puberty is largely additive in inheritance with little evidence of heterosis.

2. Inbreeding.

Data from the Front Royal, Virginia, station, where inbreeding is being carried on in several lines and breeds, indicate that inbreeding effects may be more detrimental to females than to males, as far as birth weight and daily gain to weaning are concerned. Data from this station also show a depressing effect of inbreeding on conception rate. (AH dl-4)

Colorado data show a greater amount of heterosis in female than male calves when inbred lines are crossed. Opposite results have been observed in turkeys leading to the theory that inbreeding depression and heterosis may depend to a considerable extent on sex chromosomes with effects being greater in the sex with two of these. The term "homogametic heterosis" has been coined as a name for the theory. (AH dl-16)

In the Oregon inbred lines it appears that selection was ineffective in correcting depression of preweaning gain but was effective with respect to postweaning gain and efficiency. In general, the first trait is lowly heritable, whereas the second has a much higher value. Therefore, selection should be more effective for the latter. (AH dl-19)

Utah data on inbreeding effects are as follows: Increase of 1% in inbreeding of dam decreased weaning weight of calf 1.52 pounds; increase of 1% in inbreeding of calf decreased weaning weight 0.58 pounds. (AH dl-20)

3. General.

In Montana top-crossing merit of station derived stocks is now being determined by loans of high gaining bulls to cooperative ranchers and the return of test steers from (1) these station bulls and (2) rancher-owned bulls. From these tests the value of stocks for commercial calf production can be assessed. (AH dl-17)

Results continue to show some advantage in growth rate of calves sired by bulls from production selected inbred lines in comparison with bulls

produced in breeders herds. These results have been obtained in top cross tests on commercial herds. (AH dl-13)

Top cross tests of four lines developed at Miles City, Montana, on purebred cows in Arizona failed to demonstrate overall superiority but lines 1 and 9 appeared to have merit for the production of feeder animals either at weaning or yearling age. (AH dl-2, dl-14)

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AREA NO. 3 - BEEF CATTLE - PHYSIOLOGY

Problem. Research in beef cattle physiology is required for continued improvement in the efficiency of beef production. Investigations should include all the physiological processes involved in growth, fattening and reproduction. Additional information is needed on the physiological responses to the stress of performance at varying levels and under varying environmental conditions. Additional research is also required to take the factual information obtained and apply it towards modification of existing husbandry practices.

USDA PROGRAM

This is a continuing program on the causes of reproductive failure in beef cattle and methods of controlling or improving reproductive behavior by hormonal, nutritional or other treatments. It is carried on by physiologists and animal husbandmen at Beltsville, Maryland, and at the Department's Fort Robinson, Nebraska, Miles City, Montana, and Jeanerette, Louisiana, stations in cooperation with the respective State Experiment Stations. Studies on the causes of reproductive failures are conducted with the herds at all these locations. Investigations on the relationship between reproductive performance and protein and energy intake levels are in progress at Beltsville, Fort Robinson, and Jeanerette. Also at Beltsville, studies are in progress on the reproductive performance of cattle exposed to high temperatures and humidity.

Research at Fort Robinson, Nebraska, includes studies on semen evaluation techniques, control of the estrus cycle and the relationship between anatomy of the pelvis and calving difficulties.

The Federal scientific effort devoted to research in this area totals 3.5 professional man-years of which 3.1 are devoted to physiology of reproduction and .4 to program leadership.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State experiment stations in 1961 reported a total of 14.1 professional man-years divided as follows: physiology of reproduction 8.2, environmental physiology 2.3, and physiology of growth and development or other physiology 3.6.

Several stations are conducting investigations on the effect of controlled temperature and hormones on reproduction in heifers of both Brahman and British Breeds, the nature of sterility in animals which leave herds because of failure to reproduce, the fundamental principles

related to ova transfer, and techniques for collection and transfer of ova without surgery. Studies of physiological effects of various hormone substances and developments of simplified methods for bringing groups of animals into estrus within a short period are in progress at other stations. Basic studies are being conducted on the sites of maturization of sperm. Research is being undertaken on biological measures of response to environmental stress under controlled conditions, procedures for measuring environmental responses under field conditions, and the effect of nutrient restriction following weaning on the growth of heifers and upon subsequent lifetime production. Some of the investigations seek to explain the action of hormone-compounds in promoting growth and the effect of levels of milk and forage intake at different periods on gain and weaning weight of beef calves.

There also is research on exposing male and female cattle to varying levels of gamma radiation.

The industrial research in beef cattle physiology is conducted primarily by pharmaceutical companies with some undertaken by certain members of the meat-packing industry. This work is primarily on the use of hormones to promote rapid gains. At least one organization is known to be studying the regulation of estrous cycles with hormones. Approximately 20 professional man-years is estimated as being engaged in this industry activity.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Physiology of Reproduction

1. Effects of protein-energy ratios on reproduction have been studied at the Agricultural Research Center, Beltsville, Maryland, and at the Iberia Livestock Experiment Station, Jeanerette, Louisiana. The first phase of this study has been completed at both stations with the following results: Most heifers on the low levels of energy did not reach puberty and this trend was also true for heifers on low levels of protein. However, the heifers on low protein also had a reduced feed intake and were therefore consuming low energy levels of feed. Heifers on low levels of energy and/or protein came in heat and settled when a more adequate ration was fed. Milk production and calf growth were reduced in groups on low levels of energy or protein. Interval from calving to first heat and conception was much longer in the low level cows even after they were raised to an adequate roughage ration. After heifers were placed on a high roughage ration differences in size disappeared and no differences in reproductive performance were noted.

The second phase of this experiment is in progress using 60 grade Angus heifers to investigate the causes of abnormal births and calving losses

in extremely fat heifers and compare three levels of energy and protein which are between the levels which gave the best and poorest reproductive performance in the first phase. Studies include testing the calves to determine the maternal effects on the subsequent growth and performance. (AH d2-22)

2. At Fort Robinson, Nebraska, studies were continued on effects of total feed or energy intake on reproductive processes in beef cows. Sixty-nine pregnant Hereford cows weighing an average of 1,111 lb. and having average condition grades of 6.8 in the fall, were wintered to calving on a submaintenance ration of 4.7 lb. of TDN daily. Weights the day after calving averaged 862 lb. and condition scores had gone down to an average of 3.7. Immediately after calving they were allotted to five treatments ranging from 8.5 to 25 lbs. of feed daily. Eighty-four days after calving cow weights by lots ranged from 852 to 1033 lb. and body condition scores from 4.4 to 5.8. The interval from calving to first estrus varied from 49 days for one group to 82 days for another. The percentages of cows conceiving on 1st service were varied from 31 to 87, while the percentages which became pregnant by 120 days after calving ranged from 71 to 100 for different groups. In all cases higher feed levels were associated with best performance. This experiment shows that adequate energy levels are required after calving both for prompt return to heat and optimum conception rates. (AH d1-37)

3. In an effort to predict calving difficulty in two-year-old heifers the pelvic area was measured in approximately 1,000 heifers on cooperating ranches. To date results have been tabulated from only two ranches. At Ranch I the incidence of cows having severe calving difficulty varied from 50% for those having pelvic areas less than 170 sq. cm to 11% for those having pelvic areas between 190 and 209 sq. cm. On Ranch II the incidence of severe calving difficulty varied from 49% for heifers having a pelvic area between 180 - 199 sq. cm. to 6% for heifers having a pelvic area between 220 - 239 sq. cm. Birth weights were available at one ranch. Heifers giving birth to calves weighing as much as 70 - 79 lb. had calving difficulty regardless of the size of the pelvic opening. However calving difficulty tended to be less severe as the size of the pelvic opening increased. The only severe calving difficulty encountered in heifers giving birth to calves weighing between 50 and 69 lb. was found in those heifers having pelvic openings less than 190 sq. cm. (AH d1-37)

4. In studies on estruual cycle control two hundred cycling heifers received 24 daily injections of progesterone alone or in combination with estradiol (20 mg. of progesterone with 0, 10, 20, or 40 mcg. of estradiol or 40 mg. of progesterone plus 0, 20, 40, or 80 mcg. of estradiol). One group of heifers on each level of progesterone received 20 mcg. of estradiol on the 23rd, 24th and 25th day of injection only. Twenty heifers were not treated and served as controls. Four

heifers showed estrus during the injection period. The proportion of heifers showing estrus during a 5-day period following termination of treatment varied from 68% in the group receiving 40 mg. of progesterone and 20 mcg. of estradiol on 23rd, 24th and 25th days only to 100% in the group receiving daily injections of 40 mg. progesterone in combination with 20 mcg. of estradiol. The heifers conceiving at the synchronized estrus varied from 13% for those receiving 40 mg. of progesterone alone to 56% for those receiving 40 mg. of progesterone plus 40 mcg. of estradiol. Sixty percent of the controls conceived on first service. (AH dl-37)

5. Age and weight at puberty were determined on 40 straightbred and 47 crossbred heifer calves. These represented progeny from Angus, Hereford and Shorthorn sires bred to females of their own breed and to females of each of the other two breeds. The crossbred heifers attained puberty 58 days earlier and were 27 lb. lighter than the average of the straightbreds. The difference in age at puberty was reduced to 20 days when adjusted for both 200-day weight and average daily gain from 200-396 days. Increased growth rate of the crossbred heifers appeared to account for about two-thirds of the difference in age at puberty. Straightbred Angus, Hereford and Shorthorn calves reached puberty at 382, 483, and 427 days and weighed 524, 615, and 510 lb., respectively. Differences between reciprocal crosses were negligible. Important differences in age and weight at puberty were shown among sire groups. (AH dl-12, dl-37)

6. Results from the 1961 breeding season at Fort Robinson show that cows being bred for crossbred calves had superior reproductive performance. The percent pregnant was 97% for cows being bred for crossbred calves; 91% for cows being bred for straightbred calves. Cows bred for straightbred calves took an average of 1.94 services per conception and 40% settled on first service, while cows bred for crossbred calves required 1.78 services per conception and 52% settled on first service. (AH dl-12, dl-37)

7. In efforts to find factors related to stillbirths, data were obtained over a five year period at Miles City, Montana, on blood plasma levels of carotene, vitamin A, and inorganic phosphorus in cows giving birth to stillborn calves. Detailed postmortems were made on most of 154 stillborn calves and 22 calves that died at less than seven days of age.

More male than female (83 vs. 51) calves were stillborn and the stillborn males averaged 20 lb. heavier than stillborn females. More males exhibited abnormal presentations and required birth assistance. More males showed postmortem symptoms of injury due to prolonged parturition.

Three-year-old dams had the highest incidence of stillborn calves followed by four-year-olds.

Other than symptoms of difficult birth, the most frequent clinical finding in stillborn calves was heart abnormalities including patent auricular, ventricular or auricular-ventricular systems.

Calf deaths within one week were largely due to disease with pneumonia being the most frequent.

Mean blood plasma values of cows giving birth to stillborn calves were within the normal ranges in carotene, vitamin A and inorganic phosphorus. (AH d1-33)

8. In an effort to determine supplements needed on pasture for optimum reproduction, an experiment was started at Jeanerette, Louisiana, in November, 1961, with pregnant, coming 2-year-old Angus heifers. Treatments are: Lot I, pasture only; Lot II, dry lot, fed to maintain same weights as Lot I; Lot III dry lot, fed according to National Research Council recommendations for pregnant and lactating heifers; and Lot IV, pasture with supplemental feed as needed to maintain same weights as Lot III. The study thus provides for studying reproductive performance at two levels of nutrition, in dry lot and on pasture at the same nutritive levels, and will provide two estimates of the amount of nutrients actually obtained at different seasons from mixed white clover-grass pasture at that location.

Initial weights averaged 712 lb. By June 1, 1962, Lots I and II averaged 70 lb. lighter than Lots III and IV and only 19% had been in heat as compared to 80%. The results indicate the inadequacy of pasture alone at this location for optimum reproductive performance by young cows. (AH d2-34)

9. In studies of factors affecting herd reproductive rates, breeding herds at Jeanerette, Louisiana, consisting of purebred Angus and Brahman strains based on inter se matings of Angus x Brahman and Angus x Africander foundations and Angus-Brahman 1st crosses were routinely checked for puberty, interval from calving to first estrus, and conception rate during a 75 day breeding season.

Angus heifers were youngest at puberty, Brahmans the oldest and the other three strains intermediate. Post partum intervals to estrus were longer for three-year-old cows than for older animals in all breeds and Brahman, Brahman-Angus, and Africander-Angus cows had longer intervals than Angus. Brahman cows had a lower conception rate than other types.

Heifers and cows not becoming pregnant in the regular breeding season were further investigated. A group of the open cows were placed with a fertile bull in September while lactating. Only twenty percent of the cows showing heat settled during this period. After the calves were

weaned, 50% of the cows showing heat, conceived. At slaughter, regressing embryos and membranes were found in a number of the non-pregnant cows indicating embryonic death had occurred. Abnormalities found included: (1) infantile reproductive organs; (2) double cervix; (3) lutenized follicles; (4) blocked oviducts and (5) ovarian adhesions. (AH dl-6, dl-30)

10. In experiments on temperature effects on reproduction in heifers previous work had shown that heifers placed in a heat chamber at 90° F. during the winter went through a period of heat stress but eventually shed their winter coats, resumed estrual cycles, and were fertile. To check this, six Hereford heifers were placed on experiment in December for 16 weeks. They were higher in condition and had a shorter hair coat depth than the heifers in the first trial. Hair coat depth increased slightly until the third week then remained at this level until the ninth week when the hair coat decreased. Rectal temperature and respiration rate increased markedly up to the third week then remained at approximately this level while experiencing numerous peaks and dips. In this test as stress built up the heifers would leave their feed until their temperature would drop and then start eating their feed again. During the experimental period four heifers ceased to cycle but did reestablish their estrous cycles by the 12th week.

In an effort to determine whether previous conditioning would affect responses, three groups of heifers were placed on experiment in September at Beltsville, Maryland, after a summer grazing period. One group was kept in a psychrometric chamber for 14 weeks at 90° F. The other groups were kept under prevailing ambient temperature conditions with one group having artificial light similar to that of the heat chamber while the other had natural light. The groups housed under ambient conditions showed no significant changes in respiration rate or rectal temperature but water intake followed seasonal temperature while the chamber group showed significant changes in these measurements. Hair coat depth increased slightly up to the fourth week then remained at this level for the rest of the period. Only one animal ceased to cycle during the experimental period. Indications are that a rise in rectal temperature had less effect on estrous cycle in summer-conditioned heifers.

To further test the effects of high temperature on the estrous cycle, six heifers were allowed to become conditioned to summer conditions. They were then placed in the chamber in mid-August for an 8 week period at 100° F. Body temperatures rose to very high levels and after a small drop remained at a high level for the test period. During the test period, all but one heifer ceased to cycle. This would indicate that the estrous cycle can be stopped if the heat stress is severe enough. (AH dl-30). (Also reported in Area 6)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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AREA NO. 4 - BEEF CATTLE - NUTRITION AND MANAGEMENT

Problem. Producers of beef cattle need improved feeding methods which will result in optimum pasture gains, reduced feed consumption per pound of beef produced, optimum reproductive rates and desired carcass qualities. To meet these needs much basic nutritional information is required, such as: When should beef animals be fed for maximum gains and when for more limited gains? What nutrient combinations produce rapid growth of muscle with a minimum of fat deposition? How may breeding animals be economically raised that will be capable of a high level of reproductive performance over a long lifetime? What are the nutritive contributions made by range and pasture and what supplementation is required when they are used? Research is also needed on the relation between animal production and types of shelters and equipment, feeding systems, and methods of increasing labor efficiency.

USDA PROGRAM

This is a continuing program carried on by nutritionists, biochemists and animal husbandmen on basic and applied problems related to feeding and management of cattle for beef. The work is in progress at Beltsville, Maryland; in cooperation with State experiment stations at federally-owned stations in Miles City, Montana; Fort Robinson, Nebraska; Ft. Reno, Oklahoma; Jeanerette, Louisiana; Brooksville, Florida; and Front Royal, Virginia; and in cooperation with State experiment stations at the State locations of Raleigh, North Carolina; Tifton, Georgia; College Station, Texas; and Newell, South Dakota.

The Federal scientific effort devoted to research in this area totals 10.7 professional man-years. Of this number 2.7 are devoted to digestion and metabolism, .6 to concentrates, 2.7 to forage preservation and utilization, 1.4 to nutrient requirements, 1.0 to range and pasture management, .7 to management practices, and 1.2 to program leadership.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State experiment stations in 1961 reported a total of 106.8 professional man-years in this area of which 15.3 were devoted to digestion and metabolism, 18.2 to concentrates, 26.8 to forages, 19.7 to nutrient requirements, 16.2 to range and pasture management, and 10.6 to management practices.

In the area of digestion and metabolism, the primary research is on the basic functions of the rumen, particularly the animal feed interrelationships which are responsible for bloat, efficient feed digestion, and synthesis of essential nutrients.

The ways in which concentrate feeding can be modified to improve beef cattle production efficiency are under study as follows: (1) The response of breeding or fattening animals to various forms of concentrate supplementation, (2) The value of creep-feeding, (3) The effect upon gain and feed efficiency of frequent feeding compared with feeding once or twice a day, and (4) The use of salt or gypsum to limit feed intake.

The effect upon nutritive value of various methods of harvesting, storing, and feeding concentrates are also under study.

In the forage area, investigations are underway on the effect of fertilization, time of cutting, method of storage, and methods of feeding upon the nutritive value of forages are of major concern. The development of methods for the accurate evaluation of grazed forages is under study as is the stimulation of forage digestion by ration supplementation with hormones, enzymes, antibiotics, and minerals. Several stations are cooperating in regional projects on problems in this general area.

The basic requirements of beef cattle for specific nutrients, their metabolism, interactions, and availability in feeds, constitutes a major area of work in beef cattle nutrition. Studies are underway in the following general areas: (1) The requirements, metabolism, and interactions of the many major and trace nutrients, (2) The effect of feed additives or implants upon growth and feed efficiency, (3) The relation of nutrients to metabolic disorders, such as urinary calculi and grass tetany, (4) The toxicity of molybdenum and fluorine, (5) The value of irradiated feeds in assimilation of fallout products, (6) The use of roughage concentrate ratios in chemical regulators for feed intake control, and (7) The effect of physical form of the ration upon nutritional value.

Work is underway on the evaluation of the composition of range and pasture plants, the quantity harvested by livestock, the use of pasture or range by various ages of cattle, and the effects of stocking rate upon the output of beef per acre and individual animal performance.

Studies on management practices, equipment, and facilities, include such things as various combinations of drylot and pasture feeding, maximum utilization of pasture through using late fall and early spring pasture crops and winter pastures in the South, use of supplementation necessary when low quality roughages are used by breeding animals, and creep-feeding vs. noncreep-feeding of calves.

Approximately 60 professional men are engaged by industry and other organizations in the field of beef cattle nutrition and management. The greatest portion of this work is on feed additives, supplement formulation, and comparisons of rations. Some of the initial work on all concentrate rations was conducted in the feed manufacturing industry. At least one agricultural chemical company is studying the metabolic

disorders resulting from fluorosis. There is one private research foundation engaged in studies in nutrition with beef cattle.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Digestion and Metabolism

1. Digestion Techniques.

Digestibility techniques are being studied at Raleigh, North Carolina, and Beltsville, Maryland. Data collected since 1957 on application of the chromic oxide method for estimating digestibility of complete, mixed, and pelleted rations are being summarized. Statistical estimates of error of prediction will be calculated. If the errors are within an acceptable range, the technique will be used in making routine digestibility observations which often accompany feeding trial data. The chromic oxide method has certain advantages over other indicators, such as lignin and chromagen.

Much of the recent work has been devoted to the study of certain polyphenols which might influence digestibility of sericea lespedeza. A potent enzyme inhibitor has been isolated which, in vitro at least, inhibits cellulases, pectinases, pectinesterases and amylases. This polyphenol has properties which are usually attributed to leucoanthocyanins. It gives positive tests to vanillin-HCl and HCl. The inhibitor has not been isolated in large enough amounts so that in vivo studies can be made. Inhibition of cellulose digestion has been demonstrated both in cellophane tubing in a steer with a rumen fistula and in an artificial rumen.

The inhibitor is either destroyed or changed in properties in the dehydration process. Tests have been made which show that the inhibitor is changed before it reaches the dehydrator. Samples which were taken directly from the field chopper indicated that the inhibitor is lost at this point. The loss from bruising or chopping is possibly due to oxidation, either by atmospheric oxygen or possibly by polyphenol oxidases.

Work was continued in the prediction of digestibility of forages from chemical composition. The protein of sericea does not follow the usual prediction equation for protein. Reasons for these discrepancies will be studied further. (AH d2-8, d2-14)

2. Feedlot and Pasture Bloat in Beef Cattle.

Research on feedlot bloat in beef cattle at Beltsville has been directed toward determining the importance in relation to bloat of the diluting effect of saliva on ruminal contents and of the inorganic salts present in saliva. Increased water intake and the

consumption of synthetic salivary salts by cattle did not significantly influence the incidence of feedlot bloat. The pH of the ruminal samples was higher when synthetic saliva salts were fed. Neither surface tension nor total concentration of ruminal fatty acids nor the proportion of acids were affected by treatments. Between animals there was a positive correlation between the concentration of fatty acids in the rumen and bloat. However, within animals the correlation was negative. In addition, the molar percentage of acetic acid salts in the rumen was positively correlated with bloat. There was no correlation between microbial activity of the ruminal samples and bloat.

In a continuation of studies on the effects of vegetable or mineral oil on feedlot bloat, a high incidence of bloat resulted when steers were fed a basal bloat producing ration alone or with eight percent soybean oil added. An eight percent level of mineral oil added to the ration prevented bloat entirely. Data from chemical and physical analyses of the ruminal samples taken during this experiment have not been summarized at this time.

Drenching with soybean oil at a level equivalent to eight percent of the ration tended to decrease feedlot bloat. Further, it caused an increase in the proportion of propionic acid in the ruminal fluid and a decrease in the ingesta volume increase in incubation. Earlier results on the feeding of the same amount of soybean oil mixed into the entire ration indicated an increased incidence of bloat with the addition of soybean oil with no effect on the ruminal characteristics.

Mixing mineral oil in a bloat-producing ration at levels of 0.1, 2, and 4% slightly reduced bloat at the 1 and 2% levels and markedly reduced it at the 4% level. The reduction in bloat from the addition of 4% mineral oil was similar in degree to that which resulted from the addition of 8% mineral oil in another experiment reported earlier.
(AH d2-13)

3. Cause and Prevention of Urinary Calculi.

Basic and applied studies of the cause and prevention of urinary calculi were continued at College Station, Texas, with lambs and initiated at Big Spring, Texas, with steers and lambs. Lambs are used partly as a laboratory animal for beef cattle research and partly to obtain usable information on lambs themselves. Data obtained from experiments conducted in 1958-1959, 1959-1960, and 1960-1961 were summarized and grouped together in an attempt to understand the observed variation in the occurrence of urolithiasis from year to year.

The phosphate type of calculi observed in these experiments with fattening lambs was related to an imbalance in the dietary intake of calcium, phosphorus, and potassium. Animals receiving diets high in

phosphorus and low in calcium and potassium readily developed urinary calculi while diets low in phosphorus and high in calcium and potassium were not calculogenic. The variation in the occurrence of urinary calculi over a three-year period could be explained by differences in the dietary mineral intake of calcium, phosphorus, and potassium. The results of the experiment conducted in 1961-1962 are being analyzed at present and appear to confirm the previous observations.

Results obtained from analyses of the blood and urine samples taken during the experiments indicated that changes in the dietary mineral balance significantly altered the mineral levels of the serum and urine. Lambs receiving excessive phosphorus in their diet excreted increased amounts of urinary phosphorus but decreased amounts of urinary magnesium and these conditions were predisposing to urinary calculi formation. Animals receiving the high-calcium diets had lower levels of urinary phosphorus but increased levels of urinary magnesium. Urinary magnesium was also increased by increasing the potassium in the diet. Serum levels of phosphorus and magnesium were related to the excretion rates of these minerals.

The results of these studies indicate that an excess of dietary phosphorus above the animal's requirement is conducive to the development of urinary calculi unless adequate dietary levels of calcium and potassium are present.

Other factors are, however, also related to calculi formation. Pelleting appears to increase calculi cases with $\frac{1}{4}$ -inch pellets having a greater effect than $\frac{3}{8}$ -inch ones. Form of calcium supplement may also be a factor with oyster shell having given a higher incidence of calculi than carbotex.

The combined steer and wether lamb study at Big Spring is not sufficiently advanced because of the lack of numbers to warrant any definite conclusions or trends. Based on the animals examined at slaughter, neither carbotex nor disodium phosphate had any effect on calculi formation in the steer while ammonium chloride sharply decreased stone formation. Insofar as the wether lamb was concerned, disodium phosphate did not increase the percentage of lambs developing calculi. Carbotex reduced the incidence 50% while ammonium chloride effected a 90% reduction over the control or basic ration. (AH d2-31)

4. Pesticide Residues.

Investigations of residues left by pesticides which are ingested by beef cattle were started in Beltsville, Maryland, and Tifton, Georgia. Diazinon was added to alfalfa meal and the mixture was pelleted. The pellets were fed to steers in metabolism stalls. Urine and feces were collected and frozen for analysis. No diazinon was lost

during the pelleting process but it was lost from the pellets during storage. The rate of loss is about the same as the rate of loss of carotene from alfalfa pellets. Considerable amounts of diazinon were found in the feces. However, it is demonstrated that oven drying of feces drove off diazinon so that amounts found in the feces were low. A different procedure for this determination will have to be used in future studies.

Residue studies with a pesticide, Thiodan (6, 7, 8, 9, 10-hexachloro-1, 5, 5a, 6, 9, 9a hexahydro-6, 9 methano-2, 4, 3 benzodio-xanthiepin-5-oxide), were conducted to determine the stability of the compound in mixed feeds, the physiological effects on cattle when ingested in the feed, and tissue residues and resulting metabolic breakdown products. Thiodan was added as the dry compound to the rations by careful pre-mixing of the chemical with ground corn. Pelleting an alfalfa meal ration (1900 lbs. alfalfa meal, 100 lbs. corn) did not reduce the level of Thiodan when added at a level of 10 p.p.m. A 10% loss of Thiodan occurred when the mixed ration was stored for 30 days. Steers were fed rations containing 10, 60, 100, and 200 p.p.m. of Thiodan or .15, 1.25, 2.5, and 5.0 mg. per kg. of body weight, respectively. No tissue residues of Thiodan were found in omental fat samples of 10 grams, obtained by biopsy, from steers receiving Thiodan at levels of .15 and 1.25 mg. per kg. of body weight for 30 and 14 days, respectively.

Animals fed the pesticide at a level of 5 mg. per kg. of body weight for 2 days or 2.5 mg. per kg. of body weight for 13 days developed symptoms of convulsions exhibited in the muscles of the shoulder and flank. Also, excessive salivation, sweating, and incoordination in walking were observed. These symptoms disappeared within 2 hours after removal of the feed.

The excretion of Thiodan in the feces was extremely variable. Procedures for the determination of possible oxidation products of the pesticide in body tissues, feces, and urine are being developed.

A modification of the colorimetric method for Thiodan residues as developed by the Niagara Chemical Division, Food Machinery and Chemical Division, Middleport, New York, was used for assaying for Thiodan in the feed and animal fat. The method appears to be sensitive to 1 p.p.m. (AH d2-32)

5. Microbiology of the Rumen.

Biological and chemical studies of microorganisms in the rumens of beef cattle are being conducted in order to increase understanding of the basic digestive processes which occur in grazing animals. The bacteria and protozoa found in the rumen are involved in the degradation of the digestive foodstuffs and forages. In the normal rumen, fermentation food materials are metabolized to microbial cell protein,

volatile fatty acids and gases. Abnormal rumen fermentations which ofttime result in bloat when a high percentage of grain is fed to beef cattle are characterized by the production of large amounts of slimy materials in the rumen. The slime produced by the bacteria increases the viscosity of the rumen fluid and may serve to entrap the fermented gases in a froth which blocks a normal gas eructation mechanism. Chemical analysis of the slime which was isolated by ethanol precipitation procedures indicates a composition of protein, carbohydrate, phosphorus and nucleic acids. The viscosity of the slime suspension could be lowered by acid or mild heat treatment indicating nucleic acid of microbial origin.

Microbiological studies have also been conducted on the biochemical activities of the protozoa found in the rumen of cattle. The rumen protozoan Ophryoscolex caudatus has been shown to ferment starch with the production of acetic, butyric and lactic acids plus carbon dioxide and hydrogen. Cellulose was not significantly metabolized although pectin was rapidly utilized. Plant protein sources, cottonseed, soybean and linseed meals and the C-14 labelled amino acids alanine, valine, and leucine were metabolized by the protozoan and ammonia was demonstrated as the end product of nitrogenous metabolism. Studies on the biochemistry of the ruminal protozoa are being continued in order to gain additional knowledge of the physiological function of the microbes in the rumen of cattle. It has already been established that the ruminal protozoa aid in the breakdown of plant materials such as starch and cellulose, produce fatty acids which are absorbed and used as a source of energy by the host, and that the cell bodies of the protozoa serve as a source of protein for the host. This type of information will be useful in establishing the minimal nutritional requirements of the microorganisms and thus yield practical knowledge of the nutrition of the host. (AH d2-24, d2-26)

6. Value of High-Nitrogen Molasses.

The high-nitrogen molasses studied is a byproduct of a new sugar-refining process which utilizes the ion exchange principle and results in more economical sugar production. The nitrogen is present in the molasses as ammonium salts of sulfur, phosphorus and carbon. The nutritive value of this molasses for beef cattle was studied in a palatability-toxicity test, a feeding trial and a metabolism trial.

The molasses appeared to be palatable when offered ad libitum to 8 steers on a chopped hay diet during an 84-day test period. An average of 6.4 lb. molasses and 12.5 lb. of hay was consumed per steer per day with no apparent ill effects to the nervous or digestive systems.

During a 168-day group feeding trial, steers performed similarly whether they were fed a ration containing 30% hi-N-molasses or 30% regular molasses plus urea.

There were no differences in the digestibility of the nutrients with the exception of crude protein, which was less digestible ($P < .01$) in the ration containing the hi-N-molasses. Estimates of digestibility determined in the feedlot using the chromic oxide method confirmed the trends observed using metabolism crates.

There were no treatment differences in nitrogen retention when expressed as g./day or as a percent of the nitrogen consumed.

Metabolism studies with rations containing fifty percent hi-N-molasses have been delayed because of a consumption problem. It has yet to be determined if it is a palatability or nitrogen availability problem. (AH d2-14)

7. Coumestrol in Alfalfa.

In cooperation with the Western Regional Research Laboratory, an experiment was conducted at Beltsville to compare digestibility and nitrogen utilization of high- and low-coumestrol alfalfa when fed to beef cattle. The two alfalfa meals differed in quality as indicated by a higher digestible dry matter and crude protein for the low-coumestrol alfalfa. This difference was apparently due to the fact that the low-coumestrol alfalfa was harvested at an earlier stage of growth than the high-coumestrol alfalfa. There was no apparent difference in nitrogen retention when cattle were fed the two alfalfas. (AH d2-8)

8. Anatomical and Physiological Factors Affecting Digestibility.

There is relatively little information regarding the independent contributions of the gastro intestinal tract prior to and following the abomasum to digestion. Surgical removal of the rumen has been frequently attempted, but has met with only limited success. Currently, calves are being fistulated at the abomasum and all of their dry matter in pelleted form other than that in milk is being administered per abomasum. It is hoped that information leading to a greater understanding of ruminant digestive physiology will evolve from these studies.

Studies are also in progress to determine some of the rumen factors which influence the rate of salivary secretion. Sheep are being used as pilot animals while steers will be used in the final studies. Salivary collections are by means of esophageal cannulae. Thus far only pelleted rations have been studied. (AH d2-8)

B. Concentrates

1. Feeding Value of Pelleted Feeds.

The feeding value of pelleted feed is being studied at several locations. At Tifton, Georgia, pelleted Coastal Bermuda grass hay and cottonseed meal and baled Coastal Bermuda grass hay and cottonseed meal were compared using cow and calf performance as a measure of efficiency of feed utilization. The cows ate an average of 29.5 pounds of pellets as compared to 25 pounds of baled hay per day. Pelleting the hay resulted in an increase in consumption of about 30%. Both groups ate $1\frac{1}{2}$ pounds of cottonseed meal daily. The cows eating pellets lost less weight than those eating baled hay, 66 pounds and 17 pounds, respectively. The average birth weights of calves were lighter for the cows full fed hay, 69 pounds compared to 77 pounds for calves from the pellet-fed cows. The daily gains of calves from cows on hay and pellets were 1.68 and 1.86 pounds, respectively, to about 50 days of age.

Long yearling steers weighing about 730 pounds were used to compare Coastal Bermuda grass pellets with and without concentrate with a standard control ration. Relatively good gains were made by steers fed pellets alone for 154 days or pellets plus a short feed of concentrates, but yields and carcass grades were not as high as steers in the control lot fed Coastal Bermuda hay, ground snapped corn and cottonseed meal. Steers fed only pellets until they reached the slaughter weight of the control group required 203 days. Carcasses from steers fed pellets for 203 days graded approximately the same as the control lot which received the standard fattening ration for 154 days. The results of this test suggest that relatively mature steers can reach a desirable slaughter finish when fed Coastal Bermuda pellets only if fed for a longer time than required on conventional rations.

Compared to 100% Coastal Bermuda grass pellets, the addition of shelled corn either in a pelleted mixture, mixed with Coastal Bermuda pellets or fed free choice with pellets, had no consistent effect on feed consumption, but generally increased gain, dressing percentage, and carcass grade. It was concluded that adding shelled corn to Coastal Bermuda grass either in a pelleted mixture or as a supplement to an all Coastal Bermuda grass pellet would be a desirable practice if this type of ration is to be used for finishing steers for slaughter. Feeding pellets consisting of 95% Coastal Bermuda grass and 5% molasses resulted in increased feed consumption but decreased gain.

Coastal Bermuda grass pellets were compared with a standard fattening ration consisting of ground snapped corn, cottonseed meal, and Coastal Bermuda hay using yearling steers weighing about 760 pounds. All lots of steers showed a higher rate of gain during the first half of the experiment than during the last half. Steers fed Coastal Bermuda

pellets gained more than 2 pounds per day during the first 77 days. Steers fed pellets appeared to be slightly more efficient in conversion of feed to gain. Steers fed the control had higher dressing percentages and higher carcass grades than the steers fed pellets and concentrate and pellets only. The steers on the control ration brought a higher selling price.

At Beltsville, Maryland, a ration containing 60% Bermuda grass hay in ground, heated (260° F.) and pelleted forms was compared to a 60% ground alfalfa ration when fed to yearling Hereford beef cattle. All rations contained 36% corn and 4% molasses. The animals were group fed. Steers fed the alfalfa-corn ration made greater gains (ADG = 2.47lb.) than the steers on the Bermuda grass ration. The steers fed the chopped and pelleted Bermuda grass-corn rations outgained (ADG = 1.89 and 2.00 lb.) the steers on the heated ration (ADG = 0.29 lb.). Steers fed the heated ration lost 1.37 lb./day until the ration was supplemented with protein. Steers fed the pelleted Bermuda grass-corn ration required no more feed per pound of gain than the steers consuming the alfalfa-corn ration.

Carcass data from the above experiment and an earlier trial indicated that steers fed pelleted rations tended to have heavier reticulo-rumens when the weight of the organ was expressed as a percent of the weight of the gastro-intestinal tract.

Steers fed rations which had been pelleted exhibited greater molar percentages of butyric plus higher acids in their rumen liquor than steers fed the same ration which had not been pelleted.

Physical state - animal behavior studies in which steers were fed rations ground or pelleted and high or low in roughage content indicated that animals spend less time at the feeder when fed a ration in pelleted form. It was also noted (as was expected) that animals spent less time at the feeder when a high concentrate ration was fed as compared to when a ration high in roughage was offered. Conversely, animals consuming high concentrate rations or pelleted rations visited the feeder more frequently than when they were consuming high roughage or ground rations.

There were significant differences among animals and among periods in respect to the average time spent at the feeder each day. On the other hand, the average number of visits to the feeder each day was similar from period to period. Animals differed in the average number of times they visited the feeder each day.

Replication of this experiment with fourteen-day observation periods, instead of seven, gave similar results. Furthermore, there was no difference in the results when the first seven days of observations were compared with the second seven days--thus suggesting that a seven-day observation period is adequate.

An experiment designed to test the effects of animal size upon feeding behavior is now being completed. Animals ranging from 500 to 1200 pounds in body weight are being used.

In future experiments, such factors as competition, selection, and water availability will be studied. (AH d2-28)

2. Keeping Quality of Corn.

The nutritive value of stored corn was compared with new corn in studies at Wooster, Ohio. Shelled corn grown in 1954 and stored under the Federal government loan program was found equal in feeding value to 1960 corn in a cattle feeding experiment completed recently at the Ohio Agricultural Experiment Station.

The results obtained showed no significant difference in feeding value between the ages of shelled corn with respect to average daily gains, feed requirements per unit of gain, carcass grades and dressing percentages. Moreover, both kinds of corn gave about the same results in daily gain and carcass grades when supplemented with Vitamin A.

The Ohio test supplies a provisional answer to livestock producers who have wondered about the feeding value of the millions of bushels of corn held in storage for several years by the Commodity Credit Corporation and now being offered for sale under the 1961 feed grain program.

The test was begun at Wooster on July 18, 1961, with 40 head of yearling steers in drylot and was concluded on October 10. One-half of the steers were fed on 1954 corn and the other half on 1960 corn. Both lots of 20 head each were further subdivided with one-half in each case receiving no Vitamin A supplement while the other half got 20,000 International Units of supplemental vitamin A per head daily.

The corn was ground in a hammer mill and samples of ground corn passed through standard mesh screens showed no difference between the 1954 and 1960 corn in fineness of grind. Corn was hand full fed with good quality mixed hay, soybean oil meal, salt and minerals.

Blood plasma vitamin A levels were determined at the beginning and end of the experiment. Although the feeding of vitamin A brought about a definite increase in blood plasma level, none of the steers were considered to be deficient in this vitamin.

This one short term experiment with only two lots of corn does not answer the question of feeding value for all stored corn nor does it answer the question for other classes of livestock. However, it does show no deterioration in feeding value for fattening cattle on shelled corn which had been in storage for nearly seven years. (AH d2-33)

3. Value of LPC Dried Beet Pulp in Fattening Rations.

In studies at Fort Robinson, Nebraska, one hundred and thirty yearling heifers were used to study the effect of changing the percent of LPC dried beet pulp in the ration during the fattening period.

One group was fed 50% cracked corn and 50% beet pulp. The second group was fed 80% cracked corn and 20% beet pulp. The third group was fed 50% cracked corn and 50% beet pulp for the first 28 days then changed to 55% cracked corn and 45% beet pulp. Their ration was then changed every two weeks by decreasing the beet pulp 5% and increasing the corn 5% until the ration was 80% cracked corn and 20% beet pulp. All groups were self fed after the first 28 days and had free access to alfalfa hay and a mineral supplement.

The average daily gain and cost per 100 pounds of gain for groups 1, 2, and 3 were 2.54 pounds, \$17.24; 2.16 pounds, \$18.31; and 2.36 pounds, \$17.85, respectively. (AH d2-21)

C. Forage Preservation and Utilization

1. Utilization of Coastal Bermuda Grass.

The performance of steers grazing Coastal Bermuda grass was measured in a series of experiments extending over a period of two years at Tifton, Georgia. The grazing levels were 1.5, 2.0, and 2.5 steers per acre. The steers made the best gains on pastures which were stocked at 1.5 steers per acre level. The average daily gain decreased as the stocking rate increased. However, gain per acre increased as the stocking rate increased. The increase in gain per acre between the 2.0 and 2.5 level was small. The gain per acre and average daily gain at the three levels were 337, 1.46; 362, 1.18; and 371, 0.96, respectively. Animal performance was poor and the pasture was overgrazed at the 2.5 steers per acre level. The 2.0 steer per acre pastures were slightly overgrazed.

At Tifton, Georgia, a digestion trial showed that 3-week-old Bermuda grass was not very different from 5-week-old grass. The digestible dry matter and TDN were 57.7 and 57.0% for the 3-week-old grass and 56.4 and 56.0% for the 5-week-old grass, respectively. (AH d2-3)

2. Nutritive Value of High Moisture Grain Silage.

The protein nutritive value of high-moisture grain stored in silos was measured in studies at Beltsville in cooperation with the Agricultural Engineering Research Branch.

Changes in grain harvesting methods, including the use of mechanical corn pickers and field shelling, have increased the volume of high

moisture corn. This material must be dried before storage or an alternative method is storage in silos. Little work has been reported on the effects on protein nutritive value of high moisture grain stored in silos. Eight samples of high moisture corn were taken from silos on four farms located in the Corn Belt. The samples represented different types of silos and grain with different gross appearance from different areas of the silos.

A routine rat growth method was used to estimate protein nutritive value of the samples. Statistically significant differences were found in the stored samples. Damage to protein nutritive value was found to be associated with dark brown discoloration and strong fermentation odor of the grain. (AH d2-30)

D. Range and Pasture Management

1. Range Supplementation Studies.

A project designed to determine the effect of age at first calving and level of winter feeding of beef cows on the breeding efficiency, longevity, and economic production of calves has been underway since 1948 at Fort Reno, Oklahoma, in cooperation with the Oklahoma Agricultural Experiment Station.

Of the 30 cows starting the test in the fall of 1948 on each feeding level, 16, 11, and 5 remain on the low, medium, and high levels, respectively, as of March, 1962.

The data from the original group of cows have shown that limited amounts of supplement (one pound of cottonseed meal per head) on dry weathered native grass pastures resulted in nearly an eight percent increase in the calf crop weaned when compared to the high level of supplemental winter feed (two and one-half pounds cottonseed meal plus three pounds of oats per head daily). The cost of producing 100 pounds of calf was nearly twice as much for the high level as compared to the low level (\$14.39 vs. \$7.62). Less disease loss and greater fertility were experienced among the cows fed limited amounts of supplemental feed. It required approximately $1\frac{1}{2}$ years longer for the cows in the low level group to reach mature weights. Low level feeding also delayed calving although weaning weights were only slightly affected.

In this test half the heifers were bred to calve as two-year-olds and the rest as three-year-olds to determine the effect of age at first calving on lifetime performance. Thirty additional heifers (making a total of 120) were included in this phase of the experiment. In March, 1962, there were 23 of the two-year-old group and 22 of the three-year-old group still in the herd of the 60 starting in each group. The two-year-old group had weaned more calves (533 to 482) without much difference in weaning weight (476 to 485 pounds). (AH d2-12)

2. Management on Forest Range.

Cooperative work with the Forest Service and Georgia Coastal Plain Experiment Station on problems related to grazing beef cattle in the Southern pine forests is carried out at Alapaha, Georgia. Currently this work is divided into two phases, improving herd management on forest range and integrating livestock and timber production. Herd management studies compare burned and unburned native range supplemented with improved pasture.

Calves in herds whose dams were on burned range during the spring and summer averaged 407 and 440 pounds at weaning while those in herds which were on unburned range with limited improved pasture averaged 367 and 377 pounds at weaning or an average of 51 pounds more. There was very little difference in cow weights in the spring when they were placed on pasture. By late September when the calves were weaned the average weight of the cows on the burned areas had increased 150 pounds while those on the unburned range with limited improved pasture increased 115 pounds. There is a tendency for the cows on the unburned range to make up this difference during the fall and winter when they receive a fairly good winter ration.

Earlier attempts to graze pastures seeded among newly planted pine trees resulted in severe damage to the young pines. Trees were planted on 24 two-acre plots in 1957. These plots were clean cultivated until 1960 when they were seeded to pasture. Some difficulty was experienced in reestablishing the grasses in 1960 because of a long dry period which occurred in the spring soon after seeding. As a result there were some bare spots and contamination from common Bermuda grass. The pine seedlings grew well and in November, 1961, they averaged 16.5 feet tall and 5.6 inches in diameter at 6 inches above the ground. Grazing was started in April, 1961.

In 1961, the eight pastures having no pines produced 236 pounds of live weight gain per acre as compared to 156 pounds in the 12 x 12 spacings and 208 pounds per acre in the 20 x 20 tree spacing. There was no appreciable difference noted in the individual steer performance on the pastures having the three tree spacings. (AH d3-3, d3-4)

3. Productivity of Pastures Grazed by Cattle and Sheep.

Problems related to comparative productivity of pastures grazed by beef cattle alone, sheep alone, and by the two species in combination are being studied in cooperation with the Sheep and Fur Animal Research Branch and the Forage and Range Research Branch at Beltsville.

An Orchard grass-Ladino clover pasture was laid out in two replicates. There are four treatments and two stocking rates. The treatments are: cattle alone, sheep alone, cattle-sheep in a 1:5 ratio, and cattle-sheep

in a 1:1 ratio. The stocking rates are .75 and .50 acres per animal unit. The animals were grazed 163 days in 1961. Results indicate better animal gains on the lower stocking rate and with the steers and sheep grazing together.

In September, 1961, a trial was conducted to determine the intake and digestibility of the pasture. The following analyses are being made on the composite of forage and feces: % chromic oxide, % nitrogen, % lignin, units ~~chromogen~~ % organic matter, and % dry matter.

In 1962, the second year trial was to duplicate the first year's trial but because of prolonged drouth the animals had to be removed after 58 days to prevent permanent damage to the pastures. (AH b3-10)

E. Management Practices

1. Interrupted Growth.

Carcass grades and meat quality of the animals which were re-tarded by feeding maintenance rations and then full fed were not appreciably affected by the 7-month period of low energy intake. However, there was an apparent decrease in tenderness as measured by shear and organoleptic tests. (AH d2-11)

2. Management of Cattle and Pastures for Beef Production.

Creep feeding experiments carried on for four years at Brooksville, Florida, with the Angus, Hereford, Brahman, and Santa Gertrudis breeds and a Brahman-Angus group showed wide breed differences. The creep-fed calves showed an advantage of 24 pounds over the noncreep-fed group. The average increase in weight of the creep-fed over the noncreep-fed was for Brahman-Angus 43 lb., for Hereford 37 lb., for Angus 17 lb., for Brahman 17 lb., and for Santa Gertrudis 15 lb. The carryover effect of creep feeding was studied using 69 head of 1959 heifers. The advantage of creep feeding was eliminated the following year after weaning. The noncreep-fed group was 6 pounds heavier at the end of the yearling year and made 36 pounds more gain per head than the creep-fed group. (AH d3-2)

3. Systems of Feeding and Management for Beef Production.

An experiment is being conducted at Beltsville in cooperation with the Dairy Research Branch to determine the relative merits of several systems of feeding and management for the production of beef from dairy and dual-purpose steers. Beef steers are also included in the experiments for comparative purposes.

Sixteen calves of four different breeds were put on two treatments from birth to six months. The six-month average daily gains for the calves

receiving maximum feed were as follows: 2.4, 1.8, 2.2, and 1.7 for Holstein, Angus, Milking Shorthorn, and Jerseys, respectively, and for calves on a limited-feed regime receiving milk replacer: 1.1, 0.8, 0.8 and 0.6 for the Holstein, Angus, Milking Shorthorn, and Jerseys, respectively.

At six months, calves in each group were divided into four groups as follows: (1) slaughtered at six months to obtain comparative information on body composition; (2) high concentrate ration; (3) roughage ration; (4) roughage until steers reach a given weight and then changed to the concentrate ration. These steers are all fed ad libitum. Incomplete data show that the average daily gains for the entire period were highest for the Holstein followed by Milking Shorthorn, Angus, and Jersey. Dressing percentages of these animals were rated in this order: Angus, Milking Shorthorn, Holstein, and Jersey. (AH d3-6) (Also reported in Areas 5 and 20).

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AREA NO. 5 - DAIRY CATTLE - BREEDING

Problem. Dairymen need information on genetic methods for increasing the efficiency of milk production and modifying milk composition, as well as other economic traits, in order to reduce unit costs and meet the future market demands. Precise information is needed on the relative importance of performance traits, the nature of their inheritance and their response to selection and specific systems of mating. Recently advanced genetic methods, such as those utilizing heterosis and specific and general combining ability, need to be evaluated as procedures for more rapid improvement of milk production or other important traits.

USDA PROGRAM

This is a continuing program conducted by geneticists on basic and applied studies of the inheritance of the dairy cow including experiments designed for evaluating the application of advanced genetic concepts to dairy cattle improvement. The work is in progress at Beltsville, Maryland, and cooperatively with 14 State experiment stations and laboratories in nine foreign countries. Several of the studies contribute to the North Central and Southern regional dairy cattle breeding projects. The work on performance testing includes cooperation with 50 States and Puerto Rico with the Records and Breeding Committees of the American Dairy Science Association. Cooperation is also carried out with the National Association of Artificial Breeders and with the various dairy cattle breed registry organizations.

The Federal scientific effort devoted to the research in this area totals 21.7 professional man-years. Of this number, 7.2 are devoted to genetics and interrelations of performance traits, 2.3 to performance testing, 11.0 to selection and systems of breeding, and 1.2 to program leadership.

A grant with the Agricultural Research Center, Tikkurila, Finland, provides for research on the breed differences regarding the antigenic properties of cattle blood, their inheritance in relation to economic characteristics and genetic origin of the breeds. Its duration is for four years, 1961-1964, and involves PL-480 funds with a \$61,804 equivalent in Finnish Finmarks.

Another grant with the Division of Investigaciones Agropecuarias, Ministry of Agriculture, Bogota, Colombia, supports work on the evaluation of the native breed, Costeno Con Cuernos, and Holsteins and Brown Swiss when mated and selected for dairy traits under the

hot and humid conditions of Northern Colombia. The duration of the grant is for five years, 1962-1967, and involves PL-480 funds with a \$246,000 equivalent in Colombian pesos.

Two PL-480 projects (also reported in area 6) S3 AH-7 at Sao Paulo, Brazil, and A7 AH-1, at Izatnagar V. P., India, are in effect and are pertinent to this area.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State experiment stations in 1961 reported a total of 46.5 professional man-years divided among sub-headings as follows: genetics and inter-relations of performance traits 25.6, performance testing 3.9, selection and systems of breeding 17.0. This research is currently being conducted by stations in all four of the regions with research in two regions being coordinated through the S-49 and NC-2 regional projects. Eleven stations and the USDA are cooperating through the S-49 regional project. Problems include development of adapted strains from crossbred foundations, measurement of heterosis and crosses of dairy strains, effective measures of heat tolerance in dairy cattle, and selection for productivity. Twelve States and the USDA are cooperating through the NC-2 regional project. The effort involves studies on systems of breeding, selection, and genetics of performance traits.

Estimates of genetic parameters in dairy cattle are being made from data collected in several States. Traits of the economic importance under consideration include milk production, persistence of production, feed efficiency, growth, dairy type, and milk composition. Projects aimed primarily at assessing the importance of environmental and genetic factors affecting the constituents in milk have recently been developed. Use is being made of identical twins and assessing genotype by environmental interactions. The inheritance of blood cell antigens is under investigation and attempts are being made to determine the relationships between the blood antigen picture and performance traits. Research on inheritance of congenital abnormalities of dairy cattle is also in progress.

Work is also currently in progress at State experiment stations to determine the effectiveness of mass selection for excellence in one or more dairy traits as compared to non-selected controls, inbred lines, and crosses of inbred lines. The use of proven sires as compared to young sires selected on pedigree information is also being evaluated. The degree of hybrid vigor, which may be expected, is being estimated in breed crosses in both dairy and dual-purpose cattle.

Industry and other organizations conduct very little research in dairy cattle breeding. One breed registry association spends approximately

one professional man-year conducting studies on the genetics and interrelations of performance traits and techniques of performance testing. The members of the National Association of Artificial Breeders collectively and individually cooperate with nearly all the breeding projects discussed under the program of the USDA by supplying semen for experimental matings. In addition, this group as well as breed associations supply support for studies on performance traits and performance testing in several State experiment stations. Private breeders often cooperate with State experiment stations and Federal agencies by providing data from their herds for use in research studies.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Genetics and Interrelations of Performance Traits

1. The Genetics of Feed Utilization.

These studies were undertaken to determine if there are inherited differences in the ability of growing and lactating dairy cattle to utilize feed. The research is being conducted at Beltsville and in cooperation with the Agricultural Experiment Stations of Montana, Utah and Tennessee. The Tennessee study is a contributing project to the Southern Regional Dairy Cattle breeding project.

The studies at Tennessee, Montana and Utah were designed to determine the genetic variability within the Holstein and Jersey breeds in forage utilization for production and growth. Mating plans utilize sires of diverse blood lines. Half of each resulting sire group is fed on roughage only through first lactation and the other half is given a ration of roughage plus grain.

At Lewisburg, Tennessee, a total of 98 first lactation Jerseys on the forage utilization project have completed 305-day production records; 48 on roughage only, and 50 on roughage plus grain. The average mature equivalent, fat corrected milk (ME FCM) yield for the roughage group was 9,286 pounds as compared to 11,586 pounds for the roughage plus grain group. The roughage group produced 80.0% as much ME FCM as the roughage plus grain group. Six sires have enough daughters with completed records so that sire group comparisons can be made. Assuming that the daughters on roughage plus grain produced at their capacity, the daughters of these sires on roughage alone produced 79.8, 82.7, 79.3, 76.2, 77.4 and 80.9% of their capacity. The daughters of one sire when fed either roughage plus grain, or roughage alone, produced more than any of the other groups. On roughage plus grain they produced 1,435 pounds more than the nearest group, and 1,412 pounds more on roughage alone. The results of a two-way analysis of variance showed significant differences among both

sires and feeding systems in ME FCM yield. However, the sire X system interaction was not significant. This indicates that in the preliminary data high producing progeny groups on one system were also high on the other system.

A total of 42 first lactation Holstein cows, originating at Huntley, Montana, and currently at Logan, Utah, have completed production records on the forage utilization project. This number represents the daughters of four sires. The average ME FCM yield of the cows fed hay alone was 9,319 pounds as compared to 13,348 pounds for those fed roughage and grain. Assuming that the cows on roughage and grain produced at their capacity, the cows on hay alone produced 69.3% as much. On an individual sire group basis, the daughters of 1121, 3163, 3511, and 3194 produced 76.9%, 76.1%, 67.5%, and 56.9% as much respectively on hay alone as compared to those on hay, silage and grain. When fed roughage and grain, the daughters of 3511 produced more than the other groups; yet, on hay alone, the daughters of 3511 ranked third in level of production. On hay alone, the daughters of sire 3163 produced more than the other groups, ranked second in production when grain was fed. Another striking switch in production levels were the daughters of sire 1121. On hay alone, 1121 daughters ranked second in production; however the daughters who received roughage and grain produced at the lowest level of the four groups. This reversal in the ranking of the sire groups between the two levels of nutrition was not evident in the Lewisburg data. The results of a two-way analysis of variance indicated significant differences in ME FCM yield among the two groups. The difference among sires was not significant. However, the sire X system interaction approached significance.

When the Lewisburg Jerseys are compared to the Huntley Holsteins on the same feeding regime, the mean ME FCM yield is practically the same. On a percentage basis, the Huntley Holsteins on hay alone produced only 69.3% as much as their half sib pair mates on roughage and grain, as compared to 80.1% for Lewisburg Jerseys. These results would indicate that the Jerseys may be more efficient utilizers of roughage alone for milk production than Holsteins. However, additional data is necessary before this can be considered a valid observation.

The research in progress at Beltsville to determine the value of certain feeding methods in estimating genetic differences in feed efficiency among cows is being continued. At the present time 22 cows fed at a constant rate have completed 35 lactations. Their average FCM yield was 13,951 pounds with a corresponding feed efficiency of 2.001. The standard deviation of FCM yield and feed efficiency was 1,875 and 0.25, respectively. Twenty-three cows fed according to production standards have completed 38 lactations. These cows averaged 15,195 pounds of FCM and their average efficiency of feed utilization was 1.96. The standard deviation of FCM yield and feed efficiency was 2,677 and 0.18,

respectively. These results indicate the 1,244 pound greater average yield of the standard fed cows was probably due to the difference in the average energy intake among the groups. The standard fed group received an additional 800 therms of E N E. There was more variation in FCM yield among cows in the standard fed group than in the constant fed group. This would be expected when feeding according to production and maintenance requirements, as opposed to feeding a constant energy level regardless of production and maintenance requirements. The intra class correlations (repeatability) between successive lactation for FCM yield was 0.10 and 0.67 for the constant fed and standard fed groups, respectively. The repeatability of feed efficiency was 0.20 and 0.51 for the constant fed and standard fed groups, respectively. The standard fed group was more persistent and gained more weight during their lactation than the constant fed group.

To date a total of ten cows have completed lactations on a ration of ad lib grain, hay and silage. These tests were and are being continued in an effort to evaluate unlimited feed intake in relation to feed efficiency and milk production. There appears to be considerable variation in both total yield and feed efficiency among the cows in their response to full feeding. The range in FCM yield and feed efficiency was 7,343 to 18,208 and 1.24 to 2.16, respectively. The average FCM yield for the group was 13,172 pounds of milk and a standard deviation of 3,363 pounds. The average feed efficiency was 1.63 as compared to 1.67 for their first lactation; however, the standard deviation was 0.29, which was twice as large as it was during the first lactation. Four of the ten cows were by one sire and three of these milked less than 280 days; and the fourth one produced only 500 pounds more than she did in the first lactation. The remaining six cows were by three different sires. All but one of these exceeded their first lactation ME by a considerable margin on ad lib feeding. Future efforts will be made to test at least 3 - 4 daughters per sire in order to evaluate the effect of sires. These cows consumed an average of 64.3% of their total energy in grain, as compared to 33.6% in the first lactation when fed according to the usual feeding procedures. (AH gl-4)

2. Body Form and Internal Anatomy of Cows and Milk Goats

A comparative study has been made of the external body form, internal anatomy and production records of Toggenburg goats and of Holstein and Jersey cows. The data on 14 goats were obtained through cooperative arrangements with the New Mexico Experiment Station. The data on cows were obtained on 185 Holsteins and 194 Jerseys in the Beltsville herd. In age at slaughter the goats averaged 7 years 5 months, the Holsteins 6 years 11 months, and the Jerseys 7 years 1 month. The average for each item of external and internal weight or measurement in goats was expressed as a percentage of the corresponding

weights or measurements of the combined average of Holstein and Jersey cows. The goats averaged less than 10 percent of the cows in body weight. The goats were found to be tall and long, definitely narrow bodied--particularly in the region of the pelvis--and to have short, wide heads as compared to dairy cows. On the average the goats showed slightly more wedge in depth and in width than the cows. In thoracic index--the relation of depth to width of fore chest--the goats exceeded the cows. In abdominal index--the relation of depth to width of paunch--the goats exceeded the cows to an even greater extent. Slope of rump in the goats was 31.4 degrees compared with an average of 5.7 degrees in the cows. The relatively short, wide heads of the goats are indicated by the relation of length to width--which was 1.64 in the goats compared with an average of 2.20 in the cows. Legginess, the percentage of total height below the under surface of the chest, was considerably greater in the goats than in the cows.

Comparisons made on the basis of the number of units of weight or measurement of internal organs per 100 pounds empty body weight showed that the weights of brain and pituitary were relatively about 3 times as great in the goats as in the cows; reticulum, pancreas and thyroid weights and length of large intestine were about twice as great; heart, liver, kidney, pineal and adrenal weights and length of small and total intestines were relatively one-and-one half times as great. There was relatively little difference in the weights of total stomachs or blood.

The highest actual 2X, 305-day records of production were used in determining averages for both goats and cows. The average production of the goats was 1,548 pounds of milk containing 61.38 pounds of fat and testing 3.96 percent. The average for Holsteins was 12,978 pounds of milk containing 479 pounds of butterfat and testing 3.69 percent. (Since the percentage of fat in the goats' milk more nearly approximated that of Holsteins than of Jerseys the production of goats was compared with that of Holsteins).

When measured prior to slaughter the goats averaged 111.29 pounds in weight. The average for 185 Holstein cows, prior to slaughter, was 1,343 pounds. On the basis of these weights the goats produced 13,910 pounds of milk and 552 pounds of fat per 1,000 pounds body weight. On a comparable basis the production of the Holstein cows was 9,670 pounds of milk and 357 pounds of fat. (AH gl-1)

3. Body Form of Holsteins and Jerseys at Different Periods of Life.

In studies of the growth and body form of animals in the dairy herd at Beltsville 28 body dimensions were measured and various body proportions were determined. Marked differences in variability in the dimensions have been shown. Variability was found to be lowest for

body heights and next lowest for body depths. The highest variability was for body widths. Among the body proportions studied legginess showed the lowest variability, followed by wedge based on depths and wedge based on circumferences. Aside from a higher variability at 3 months there was little change with age in variability for the various groups of dimensions or for the body proportions mentioned.

Although variability in most measurements remained nearly the same during life, some of the body proportions themselves underwent substantial changes, that is, the animal did not grow symmetrically. Average results for Holsteins and Jerseys show that height at withers was 3.3 percent less than height at hips at 3 and 9 months, 2.4% less at 12 and 18 months, and 0.6% less at first and second lactations, but 0.3% greater at maturity. A much greater change occurred in the relation of body length (withers to pinbones) to height at withers. Body length averaged 15.1% less than height at 3 months, 7.5% less at 6 and 9 months, and 2.8% less at 12 and 18 months. At first and second lactations, however, body length was 3.0 percent greater than height at withers, and at maturity it exceeded wither height by 6.3%. A marked change was found to occur also in the relation of hip width to thurl width. Width of hips was 11.1% less than width at thurls at 3 months, 4.0% less at 6 and 9 months, and 2.6% less at 12 and 18 months. Hip width, however, was 11.4% greater than thurl width in first and second lactations and 13.0% greater at maturity. The change from a lower to a higher relative width for hips occurred at a younger age in Jerseys than in Holsteins. The ratio of head length to head width (at forehead) increased progressively from 1.41 at 3 months to 1.85 at maturity, while the ratio of head length to body length (withers to pinbones) decreased progressively from .412 to .367. The ratio of depth to width of chest averaged 1.85 at 3 months and 1.74 at 6 months. It remained at approximately 1.68 to 1.70 at later ages. Ratios of depth to width of paunch, however, declined progressively from 1.32 at 3 months to 1.08 at maturity.

Further evidence that animals do not grow symmetrically is brought out by differences in percentages of maturity at 3 months of age for various groups of dimensions. For Holstein and Jersey females the average percentages were 66.9 for heights, 62.3 for head measurements, 53.0 for body lengths, 51.0 for body depths, 49.4 for body circumferences, 44.0 for pelvic widths and 43.8 for widths of the barrel (chest and paunch). Breed differences in these percentages were small except for widths and circumferences of the barrel which were considerably higher for Holsteins than for Jerseys. (AH gl-1)

4. Body Measurements of Holstein and Jersey Cows and their Records of Milk Production.

Determinations have been made of the relationships between body measurements recorded during both first and mature lactations and

records of production. Simple correlations were determined between each measurement recorded during first lactation and both the first lactation M.E. and the highest production, and also between each measurement obtained at maturity and the highest M.E. production. The analyses involving first lactation measurements included 478 Holstein and 343 Jersey cows; those involving mature lactation measurements included 211 Holstein and 162 Jersey cows. Partial correlations, independent of live weight, also were determined for many of the 28 items of measurement to show the extent to which the more significant associations indicated by the simple correlations would hold if the effects of body weight (size) were eliminated. In almost every instance with Holsteins the partial correlations were lower in magnitude than the simple correlations, changed from positive to negative, or became more highly negative. The first lactation measurements having the highest association with first lactation M.E. milk production were depth of paunch (0.343), depth of rear chest (0.338), circumference of paunch (0.276) and head length (0.246). Partial correlations for these items were 0.313, 0.316, 0.217 and 0.179, respectively. Between first lactation measurements and highest M.E. production the same items of measurement showed the highest correlations and the correlations were similar to the others in magnitude. For most items the associations between mature lactation measurements and highest M.E. production were lower than those based on first lactation measurements. One exception was head length which had the highest correlation (0.285) followed by depth of rear chest (0.256), depth of paunch (0.228) and depth of fore chest (0.197). Corresponding partial correlations were 0.233, 0.228, 0.154, and 0.113. It appears that at least a portion of the associations between body dimensions and production in the Holsteins was the result of greater body size (weight).

Associations were lower in nearly all cases for Jerseys than for Holsteins. About half of the correlations were negative. The first lactation measurement having the highest association with production was height at withers (0.125 for first lactation M.E., and 0.122 for highest M.E. production). Head length ranked second with correlations of 0.114 and 0.101. Among associations of mature lactation measurements with highest M.E. production, head length was highest (0.199). In Jerseys the partial correlations tended to be relatively higher instead of lower than the simple correlations as was the case in Holsteins. However, the magnitude of the correlations in Jerseys was too low in most cases to be considered important. (AH gl-1)

5. Milk Production as Related to External Body Measurements and the Weights and Measurements of the Internal Organs.

One hundred and eighty five Holstein and 194 Jersey cows from the Beltsville herd were included in these body form-internal anatomy-production studies. Since this represents different samples of the herd than those used in correlating mature measurements in the body

form-production studies, and since the measurements were obtained at a different time, it was not expected that the results would be the same. The five highest simple correlations between milk production and individual body measurements in Holsteins ranged from 0.352 for length, withers to hips to 0.275 for depth of paunch and included length, withers to pinbones (0.329), depth rear chest (0.276). In Jerseys the simple correlations ranged from 0.250 for head length to 0.197 for length, withers to pinbones. Included in this range were length of loin (0.249), height at withers (0.229) and length withers to hips (0.223). The magnitude of the simple correlations was considerably higher than those obtained in the similar study of body form-production relationship. This was particularly the case in Jerseys. Although as in the other analysis, the partial correlations, independent of live weight, tended to be lower than the simple correlations in Holsteins and higher than the simple correlations in Jerseys, the differences were less marked. The correlations between milk production and body measurements appear to have been only slightly affected by live weight.

Greater consistency in results is shown in the relationship between milk production and the weights of the internal organs (including blood) and length of intestinal tract. The simple correlations tended to be higher in magnitude than those for body measurements, especially in Jerseys. The seven highest positive correlations ranged from 0.402 for length of total intestine to 0.260 for weight of pituitary in Holsteins, and from 0.449 for blood weight to 0.192 for lung weight in Jerseys. Six of the seven items having the highest positive simple correlations were the same in both breeds. In the order of the highest rank for both breeds these items were: weight of blood, length of total intestine, and the weights of liver, kidneys, total stomachs and lungs. Although separate correlations were determined for each of the 4 divisions of the stomach and for small and large intestine only the totals were considered in listing the highest correlations. As in the case of external body measurements the partial correlations, independent of live weight, were slightly lower than the simple correlations in Holsteins and tended to be relatively higher in Jerseys. Associations indicated by the simple correlations for the items of both external form and internal anatomy appear to be largely independent of live weight. (AH gl-2 and gl-3)

6. Genetic and Phenotypic Relations Between Production, Udder Palpations and Body Measurements.

An investigation during the past year has included the analysis of the genetic and phenotypic correlations between production, udder palpation, and body measurements at Ohio.

The genetic correlations were computed from within-herd and sire correlations of 447 daughter's traits with their dam's traits. Phenotypic correlations were computed on a within-herd basis.

Analyses indicated a few significant phenotypic correlations between production and other traits. The traits having significant phenotypic correlations were gland width and gland grade with milk and fat production (.174, .170, .138 and .135), 5-month body weight with milk production (.113), and 3-month after calving body length with fat production (.118). Genetic correlations were, in general, low in magnitude for udder palpation and 6 months measurements. Genetic correlations between production and yearling measurements were in general higher than those involving 3-month. After calving measurements, however, the 3 months A. C. height at withers gave the largest genetic correlations (.419 and .354).

Genetic and phenotypic correlations between measurements taken at the same time and at different times were of rather high magnitude. (The phenotypic correlations ranged from .252 to .770 and the values for genetic correlations, excluding six month's measurements, ranged from -.807 to 1.235).

The heritability estimates for the various traits studied ranged from zero, for most 6-month's measurements, to .57 for gland stage. The estimates for body measurements at 6 months were very low (the values ranged from zero to .10), values were low to moderate for yearling measurements (.09 to .36), and moderate to high for measurements on lactating cows (.24 to .52). The heritability estimates for udder palpation measurements ranged from .29 to .57. Estimates of heritability for milk and butterfat were .33 and .32.

A second study was completed to determine the effectiveness of using udder palpation information as an early indication of a sire's proof. When a sire's predicted proof (predicted by using the index in the Inter-regional palpation bulletin) was correlated with his actual proof, there was very little gain in accuracy realized by adding palpation data. It was concluded, therefore, that udder palpation measurements did not effectively differentiate between the capabilities of sires to transmit production traits. (AH gl-1 and gl-3)

7. Meat Production from Beef, Dual Purpose and Dairy Steers.

This study was initiated in cooperation with the Beef Cattle Research Branch to determine the relative merits of various breeds of cattle and different management systems in the production of meat. Angus, Milking Shorthorn, Holstein and Jersey calves were used and comparisons made on total gain, daily rate of gain, feed efficiency, economy of gain and quality of beef produced.

Sixteen animals of each breed were divided at random into two treatment groups from birth to 6 months of age. Treatment A was fed for maximum gains by feeding up to 40 pounds of whole milk daily and a

fattening ration free choice until 180 days of age. Treatment B was fed whole milk for 7 days and then changed to a milk replacer until two months of age. From 7 days of age until 180 days of age a maximum of 3.0 pounds of calf grain was fed per day in addition to all the alfalfa and timothy hay they would consume.

At 180 days of age 1/4 of each breed group, except Jerseys, (2 from treatment A and 2 from treatment B) were slaughtered for carcass evaluation studies. The following results pertain only to the slaughtered animals.

In both treatment groups the average 180 days weights were highest for Holsteins, followed by the Milking Shorthorns and then Angus. The average daily rate of gain followed a similar pattern.

Live animal grade prior to slaughter favored the Angus and Milking Shorthorns as compared to the Holstein. A similar pattern was found on the carcass grades.

The dressing percentages (based on hot carcass weight) in the treatment A calves were 61%, 60% and 50% for Milking Shorthorns, Angus and Holsteins, respectively. On treatment B the dressing percentage was 48%, 48% and 44% for the Holsteins, Milking Shorthorns and Angus, respectively. In order to evaluate tenderness, the Warner-Bratzler shear test was used. On treatment A the Angus were most tender, followed by Milking Shorthorns and Holsteins. In the treatment B group the Holsteins were the most tender, followed by the Angus and the Milking Shorthorns.

The difference between the treatment groups for each breed can possibly be attributed to the level of nutrition received. Group A calves consumed nearly 3 times as much total energy during the 180 day period than the Group B calves. The Group B calves on the average did not consume enough total energy to maintain what would be considered as a normal growth pattern.

The treatment B calves of the 1st phase of the experiment (birth to 6 months of age) for all breeds were more efficient (on each of the feeding regimes) than the treatment A calves. All calves of the first phase fed hay only during the 300 days of the 2nd phase were more efficient than the calves fed fattening ration in all the breeds except the Milking Shorthorns. There was no apparent difference in the relative level of efficiency among breeds for steers fed hay only. However, for those steers fed fattening ration only, the Milking Shorthorns were more efficient than the other breeds. Economy of gain followed a similar pattern among each of the breed groups.

On a breed group basis, these results indicate that Holstein steers fed hay only have outgained all the other breeds; followed by the Milking

Shorthorns, Jerseys and Angus. However, the Milking Shorthorn steers seem to have a slight edge over the Holsteins when fed a fattening ration and the Angus are somewhat better than the Jerseys. However, on hay only, the Angus steers are gaining less than 1 lb./day, whereas the Jerseys are gaining over 1 lb./day.

Final slaughter weights for the steers on this project are 1,200 pounds, 1,150 pounds, 1,000 pounds, and 900 pounds for the Holsteins, Milking Shorthorns, Angus, and Jerseys, respectively. To date a total of 10 steers have been slaughtered, 5 Holsteins, 4 Milking Shorthorns, and 1 Angus. The average number of days fed on the 2nd phase of the experiment was 411, 421, and 508 for the Holsteins, Milking Shorthorns and Angus, respectively. The average total gain and daily rate of gain was 715 and 1.74, 812 and 1.93, and 644 and 1.39 for Holsteins, Milking Shorthorns, and Angus, respectively.

The average slaughter and carcass grade for the 5 Holstein steers was medium. Their dressing percentage averaged 57%. The 4 Milking Shorthorns graded high medium with a 59.8% dressing percentage. (AH d3-16). (This work is also reported in Area 4, Beef Cattle - Nutrition and Management, and in Area 20, Production Influences on Animal Products).

8. Genetics of Milk Constituents

The purpose of this work is to study the genetic and non-genetic influences which affect the production of solids-not-fat, protein and other constituents in milk of individual cows. Cooperative efforts are continuing in organizing this work on a national basis. Projects have been formalized in many of the States and many of these have been incorporated into the regional dairy cattle breeding projects. A recent report indicates that there are 13,270 Holstein cows in the SNF testing program. However, only 900 of them are in the Northeastern region and only 5,000 are being tested for protein. The approximate numbers available for the other breeds are: Guernseys, 2,900 SNF and 1,650 protein; Jerseys, 3,600 and 1,500; Ayrshires, 390 and 320 and Brown Swiss 750 and 450. It is estimated that 6,000 cows per breed per year for five years are needed to adequately determine genetic relationships. The program needs to be expanded if there is to be any hope of getting reliable information on breeds other than Holstein. As the cooperation develops an increasingly important problem of obtaining support for assembly and analysis of the data faces the committee which is attempting to coordinate this work. There is a rapidly developing interest by the dairy industry in the possibility of evaluating milk on the basis of protein or some other constituent rather than fat alone.

At Beltsville the program of monthly testing for protein which began June, 1960, is continuing using the Orange G dye-binding method. Various modifications of the test have been studied. The time-consuming filtration step has been eliminated by adding carbon tetrachloride

to the milk and dye reagent. This dissolves the fat and eliminates a fatty deposit on the surface of the solution which had to be removed by filtration. A study of 28 split samples indicated that the addition of 2 ml of CCI 4 does not cause a significant increase in the Optical Density reading of the sample. However, the resultant average decrease in the protein percentage is 0.14. Therefore, if CCI 4 is used, a correction should be made or the standard curve relating grams of dye bound (Optical Density reading) and Kjeldahl protein should be established with samples containing the CCl_4 . Also, the need for a mechanical shaker has been eliminated. A study of 60 split samples failed to indicate a difference between samples shaken for 10 minutes on a mechanical shaker as compared with those shaken for approximately 30 seconds and allowed to stand for 30 minutes.

Seventy-three cows have completed lactations in which their milk was tested for fat, SNF and protein. They averaged 15,902 pounds milk, 4.13% fat, 656 pounds of fat, 8.91% SNF, 1,416 pounds SNF, 3.20% protein and 508 pounds protein (2X 305 ME). Sixty-four of these cows were Holsteins, eight were Ayrshire-Holstein crossbreds and one was a Brown Swiss-Holstein crossbred. The following correlations were calculated on the basis of lactation averages: % Fat and % SNF 0.53, % Fat and % Protein 0.33, and % Protein and % SNF 0.48. The correlation between protein and SNF is lower than expected in comparison with other reports.

A summarization of 276 lactation records on Holstein cows whose milk was tested for fat and solids-not-fat has been made. The within-sire correlation between percent fat and percent solids-not-fat was 0.49. The 276 records averaged $8.85 \pm .28\%$ SNF and $3.91 \pm .36\%$ BF. Daughters of 17 sires were included in this preliminary analysis. The sire group with the highest average SNF percent contained 14 cows (26 records) with an average of 9.11% SNF and 4.06% BF. The lowest was a group containing 19 cows (30 records) that averaged 8.56% SNF with 3.84% BF. A breakdown of records by month of calving indicated that cows calving from October through April produced more milk, fat and SNF on the average than cows calving in the May to September period. Percent fat and SNF were lower from October through April than during the other period.

At Michigan, the accuracy of the Golding plastic bead method has been tested under field conditions with DHIA supervisors doing the testing. Samples from a total of 42 cows were tested by seven DHIA supervisors. Aliquots of the same samples were tested by a laboratory technician using both the Watson and Golding methods. For the plastic bead method the average differences between duplicates in the field, between duplicates in the laboratory, and between the average of duplicates in the field and the average of duplicates in the laboratory were .07, .14 and .16% SNF, respectively. In all but one case the laboratory

results were higher in percent SNF. The within-tester correlations between plastic bead determinations in the field and the laboratory, between duplicate measurements in the field, and between duplicate measurements in the laboratory were .86, .91, and .86, respectively. The correlations between SNF percentages calculated from bead determinations in the field and lactometer determinations in the laboratory between the bead determinations in the laboratory and lactometer determinations, and between duplicate lactometer measurements in the laboratory were .94, .95 and .98, respectively. These results indicate that the Golding plastic bead method is suitable for field use.

At Wisconsin the solids-not-fat content for 325 lactations was studied to determine the effect of season of freshening, parity, sires and cows on variations in this trait. Although lactation solids-not-fat content varied significantly with the month of first test, seasonal trends were not evident. Records of first, second and third lactations were classified by sire and parity. Both sires and parity were significant sources of variation, but no interaction was found between the two. The means for the three parities were 8.81, 8.78, and 8.68% SNF, respectively. After adjustment for parity, 77 cows by 19 sires were available for estimating repeatability and heritability. The estimates were 0.82 and 0.36, respectively.

Cooperation with the Eastern Utilization Research and Development Division in studies of milk proteins is continuing. Recently, a heterogeneity of alpha casein was discovered which has not been described previously. Furthermore, the heterogeneity appears to be genetically controlled. Starch-gel-urea-electrophoresis reveals two alpha bands in the casein from some individual cows. The variants are referred to as alpha-A and alpha-B in order of decreasing electrophoretic mobility. Most individual milks contain alpha-B casein. Milk samples from 6 of 135 cows in the Beltsville herds show both the alpha-A and alpha-B bands. These six are paternal half sisters. Seven other daughters of the same Holstein bull in the Beltsville herd had only alpha-B casein in their milk. Milk from 80 other daughters of this same bull was studied along with milk from the dams of 30 of these daughters. Forty-three of the daughters had alpha-A/B casein as opposed to alpha-B in the others. One dam had alpha A/B and the other 29 had alpha-B. Thirteen daughters of the alpha-B dams had alpha-B casein while 16 had alpha-A/B. The one alpha-A/B dam had an alpha-A/B daughter. It appears most likely that these variants are determined by a pair of codominant alleles or that the alpha-A is determined by a low frequency dominant gene. Additional data is being collected to elucidate the genetics of this polymorphism. An interesting aspect of this work is that the bull that has been found to transmit the alpha-A casein is also a carrier of the congenital metabolic disease porphyria. Porphyria is reported to be caused by a recessive gene and studies are being made to determine if there is any genetic linkage between the porphyria condition and the alpha-A casein. Milk samples

from six cows affected with porphyria were examined but none had the alpha-A casein. This indicates that very close linkage of the genes or pleiotropy are not involved but studies of other porphyric animals and daughters of porphyria carrier bulls are continuing. It is still a possibility that the test for alpha-A casein may be useful in detecting porphyria carriers. (AH gl-5)

9. Immunogenetic Studies of Semen.

Sperm and seminal plasma are known to contain antigens but whether or not these vary, either within or between individuals, is not known. If genetically controlled variation exists for sperm antigens, as it does for red blood cells, it may be possible to select types of sperm, by serological methods, for use in artificial insemination. Studies of bovine semen antigens have been initiated at Beltsville. Two steers, one cow, and eight rabbits were immunized with semen from one of two bulls. Difficulties encountered previously in producing antibodies in cattle against bull semen were eliminated by mixing complete Freund adjuvant with the semen used for injection. This adjuvant is a mixture of mineral oil, lanolin and killed *Mycobacterium butyricum* which enhances the antibody response. Agar-gel diffusion studies confirmed the finding of several antigenic components in bull semen by Michigan workers. Analyses of the antisera against the semen of the two bulls is being made in an attempt to detect differences. (AH gl-7)

10. The Genetics of Blood Antigens in Dairy Cattle.

This work was undertaken to help coordinate and to study activities of blood antigen laboratories in this country and others in regard to repeatability of blood typing tests and comparison of reagents. Blood samples from 40 animals are sent out annually from Beltsville for concurrent analysis by blood antigen laboratories in California, Ohio, Wisconsin, Norway, Sweden, Denmark, Holland, Germany (Gottingen and Munich), South Africa, Finland, Belgium and France. The eighth trial in this program was held in January, 1962. Thirteen laboratories participated.

Studies on blood antigen characteristics were made on the Ohio NC-2 project cattle. Approximately 700 animals representing 22 different sires were studied for differences in birth weight, rate of growth, milk production, fat production, maturity index, weight of first calf and reproductive performance between the heterozygote for the A Locus and the other genotype. An estimate of differences indicated better production for animals heterozygous for the A group by 464 pounds of milk and 10 pounds of butterfat. The other traits tested were not significantly different. When the analysis was repeated on an intra-herd basis, these differences disappeared and showed no advantage for heterozygous A animals.

The Ohio laboratory is continuing the blood typing of cattle in the NC-2 breeding project. Approximately 1,000 animals were blood typed in 1961. A study was made of the application of elution techniques in the preparation of blood typing reagents. The general procedure in producing blood typing reagents has been to absorb antibodies from an antiserum containing different kinds leaving antibodies for only one antigenic factor. Red blood cells with appropriate antigenic factors are used for the absorptions. The practice has been to discard these cells and the antibodies they absorb. A heat elution method has been used to recover antibodies from the absorbing cells. These antibodies are then available for reagents. Eighteen eluates were prepared from three heteroimmune and six isoimmune sera. Results indicate that considerable antibody can be recovered by this technique. Maintaining the heat at 56° C. during centrifugation was found to be important in recovering antibodies by this process. Three reagents prepared from the eluates were used in standard blood typing tests and the results indicate that the type of reagent can be as reliable as those developed in the conventional manner.

Blood typing of the cattle in the Beltsville breeding herds is continuing. To date, 258 animals from the commercial crossbreeding herd and 361 animals from the Holstein experimental herd have been blood typed.

In the Finland PL 480 project 14 antisera have been produced for use as blood typing reagents. Immunogenetic studies are being made on progeny and other relatives of a bull whose calves were often hairless and born following a prolonged gestation. Indications are that this is a recessive lethal factor and not closely associated with any of the blood group genes studied. However, it is possible that the blood factor L' in the C-system is associated with the lethal and data are being collected for further study. (AH gl-6) (PL 480 E8-AH-1)

B. Performance Testing

1. Sire Proving Program.

The process of converting the manual punch card system of handling data and the compilation involved in the sire proving work to an automatic data process (ADP) 705-III system has been completed. Subsequent to this conversion, a complete reassortment of all dairy performance records on file was accomplished to enable sire proving to be based on a daughter-herdmate comparison rather than the daughter-dam comparison previously used. This action was taken for the purpose of increasing the efficiency of sire evaluation and conformed to recommendations of leaders of the industry assembled in a work conference to consider this problem.

The ADP sire-proving procedures were operated in July and August. In

this operation, incoming current lactation reports, as well as records in the Master File were given an extensive audit to bring the data to be used in sire proving to a high standard of completeness and accuracy. After the audit, there remained more than 6,000,000 records in the Master File. Approximately 600,000 were "pulled" from the Master File for correction, reconciliation or discard. A summary was made of the 10,095 proved-sire records of sires proved or reproved showing that 4,472 of the sires maintained or increased milk production in the herds in which they were used. A total of 5,267 or 52 percent of the sires had daughters averaging more than 11,500 pounds of milk. Also, 701 or 7 percent had daughters averaging more than 14,500 pounds of milk. Collectively, the sire records included 190,354 dam-and-daughter comparisons. The average of all the dams was 11,535 pounds of milk and 436 pounds of butterfat. The daughters averaged 11,377 pounds of milk and 437 pounds of butterfat. Data included in the proved-sire records were dam-and-daughter comparisons, daughter-herdmate comparisons and daughter-herd-average comparisons. Copies of the proved-sire and daughter-average records were sent to the State Agricultural Colleges for distribution to herd owners.

Special AI tabulations were compiled of the records of 7,618 sires used in AI studs since 1939. These tabulations give a statistical history of the AI program in this country in addition to showing the daughter averages of sires by States, and level of production. The tabulations included the records of 461,110 daughters having a total of 907,581 lactation records. These daughters averaged 9,637 pounds of milk and 404 pounds of butterfat. These tabulations were basically "working tool" material. They were printed and distributed to State Extension Dairymen and AI stud managers only. (AH i4-1)

2. Dairy Recordkeeping Programs.

Participation in the dairy recordkeeping plans of the National Cooperative Dairy Herd Improvement Program continued to increase during the year. The number of cows and herds included in the program is as follows:

<u>Plans</u>	<u>Herds</u>	<u>Cows</u>
Standard DHIA	42,034	1,958,355
Owner-Sampler	24,954	698,302
Weigh-a-Day-a-Month	<u>1,936</u>	<u>70,617</u>
Total	68,924	2,727,274

More herds and cows are in the overall recordkeeping program than ever before. The 1,395 dairy herd improvement associations employing 2,448 supervisors (testers) provide the organizational machinery for operating the program in the various States. Some 20 States now have State-wide

DHIA Cooperatives. Encouragement is given the other States to organize State DHIA's, so that the dairymen themselves may have a greater and greater part in the actual operation of the program at the State level. For the last several years, all States have been encouraged and assisted in converting their manual method of calculation of month-to-month records to automated procedures using electronic data processing equipment. Ten State or Regional DHIA Computing Centers are now in operation. ADP recordkeeping is now available to DHIA members in every State. Some ADP recordkeeping is being conducted in every State with the exception of Hawaii.

The Artificial Insemination Program (AI) through which the superior sires discovered and developed in DHIA herds are utilized, continued to grow during the year. During 1961, 863,781 herds were enrolled in the program. During 1961, 7,482,740 cows were bred artificially. This represents 39% of the nation's dairy cows of breeding age.

On January 1, 1961, there were 2,486 sires in 56 AI studs. Of this number, 488 or 19.6% were proved during 1961, using records of AB progeny only. The 488 sires were mated to 47,577 dams averaging 11,181 pounds of milk and 445 pounds of butterfat. Their progeny averaged 11,172 pounds of milk and 452 pounds of butterfat. (AH i4-2)

3. DHIA Record Analyses.

For the first time, the yearly DHIA herd records were compiled and analyzed using ADP-705-III procedures. The resulting tabulations were the most complete and extensive ever produced. The use of ADP procedures emphasized more than ever before the necessity for complete yearly reports free from errors, omissions and discrepancies. As these tabulations are valuable to the various States in their general dairy extension programs, it is expected that greater effort will be exerted in future years to have the yearly herd records reported more completely and accurately. A summary of the herd records based on 1,280,789 cow-year records showed that average production of DHIA cows for the record year 1960-61 was 10,796 pounds of milk and 418 pounds of butterfat. This is the highest yearly average to date by DHIA cows.

Copies of the State and national summaries of DHIA yearly herd records are furnished the State Extension Dairyman in each State and general summary information is published for general distribution in the Dairy-Herd-Improvement Letter. (AH i4-3)

C. Selection and Systems of Breeding

1. Comparisons of Inbreeding and Outbreeding.

This research was undertaken to determine the effects of inbreeding, outbreeding and interline crossing on production and other

economic characteristics of dairy cattle. It is conducted cooperatively with the Wisconsin Agricultural Experiment Station and is a contributing study to the North Central Regional Dairy Cattle Breeding Project.

The development of six inbred lines of Holstein-Friesian cattle, crosses between the lines and maintenance of controls have been continued. Studies of the effect of system of mating on the growth of animals in the six lines were made. Body weights and measurements were taken at 3, 6, 12 and 18 months and 3 months after first and second calvings. The measurements taken were body weight, height at withers, length of withers to pins and width at hips. Contemporary comparisons were made between the Ox group (outbred daughters of outbred foundation dams and sires) and the $Ix < .28$ (Inbreds) and also between the Cx group (outbred descendants of Ox females and by A. I. sires) and the $Ix > .29$, two-way linecross and three-way linecross females. The differences between the inbreds and their contemporaries are large at young ages and tend to decrease as animals get older. The intensely inbred females are more different from their contemporaries than are the less intensely inbred group. The two- and three-way linecrosses are approximately equal to their outbred controls.

The variation in weight and body measurements of the project animals was investigated. Data on 559 single births were available for the study. These calves were produced under five systems of mating (O-O, I-O, I-I, 2Lx, 3Lx) and represented six sire lines. Dependent variables included: weight, depth of chest, heart girth, width at hips, length from poll to muzzle, width at eyes, shinbone circumference, and length of gestation. A model was fitted to estimate the influence of mating system, sire line, system line interaction, sex, parity, season and year-period. Results indicate the system-line interaction was a significant source of variation in all measurements and gestation period. The main effects except for year-period were significant in most cases. However, system of mating showed no effect on length of gestation, depth of chest, width at eyes, and circumference of shinbone.

Line crosses and inbreds. A simple model which provided a measure of interaction among sire and dam lines was used for the data on body measurements of 93 to 219 females at birth, 6, 12, and 18 months of age, and after first calving. The females consisted of inbreds from inbred dams and outbreds from inbred dams. A significant interaction was found in most cases and indicated that differences between mating systems (inbreeding and linecrossing) varied from line to line. Further analyses were made using a more complicated model for independent estimates of heterosis, line-inbreeding effects, general combinability and maternal effects. Estimates of heterosis (differences between inbreds and linecrosses) were highly significant with few exceptions. There also were significant differences among the inbred lines. However, general combinability effects and maternal effects failed to show significance in most measurements at the different ages.

Linear regression estimates of inbreeding effects. Inbreeding effects on body measurements were also studied by linear regression. At different ages there were available 174 to 329 animals which were outbreds and inbreds from outbred dams (O-O and I-O) and inbreds from inbred dams (I-I). At birth inbreeding of calf showed heterogeneous effects among lines in chest depth, width at hips, poll to muzzle, width at eyes and gestation length. Calves were 2.4 pounds less in weight and 0.6 cm. less in heart girth for each increase of 10% inbreeding. Inbreeding of dam had significant effects on those measurements on which inbreeding of calf showed heterogeneous effects among lines. There was a 0.1 to 0.3 cm. increase in these measurements for each increase of 10% inbreeding of dam. No interaction between line and inbreeding of dam was observed.

Both inbreeding of calf and dam showed significant effects on most body measurements at 3 and 6 months of age. The former had a depression effect and the latter caused an increase. For body weight at 3 months there were 7.6 pounds decline and 7.4 pounds increase for each increase of 10% inbreeding of calf and dam, respectively, while variations among lines were held constant. For 6-month weight the corresponding changes were -14.1 and +9.0 pounds, respectively.

At 12 and 18 months of age and after first calving the effects of individual's inbreeding coefficient were heterogeneous among lines in most tests. Thus no general effect of inbreeding can be stated for various body measurements at these ages. (AH g2-5)

2. The Relative Importance of General and Specific Combining Ability in Relation to Breeding Dairy Cattle.

These studies were undertaken to determine the relative importance of general and specific combining ability between lines of dairy cattle within the same breed. They are designed to study the genetic methods needed for utilizing the nonadditive genetic variability which may be present in the economic characteristics of dairy cattle production. Projects are cooperative with the Minnesota and Ohio Agricultural Experiment Stations and are contributing projects to the North Central Regional Dairy Cattle Breeding Project.

At Minnesota the line development program with the Holstein herds at Crookston, Morris, and Rosemount were evaluated by computing the average relationship between pairs of milking linemates in both lines. Results indicate that the line development process is in its very early stages. The relationship between pairs of animals in the different herds making up one of the lines is less than 2%. The Crookston herd was brought into the line breeding program later than were the other two herds which partially accounts for the low relationship between animals at Crookston and Morris. At Rosemount the breeding during the past year has been almost exclusively to one sire and to

a son of this sire. These bulls are related to most of the young cows and heifers in the herd, hence the degree of relationship and of in-breeding should increase rather rapidly.

At Ohio the line development program has progressed to a point where the majority of animals in four different herds and lines are 25% or more related to each other. In addition to continuation of the lines a systematic scheme of line crossing has been initiated. Four lines are being crossed in all possible combinations with each other.
(AH g2-22)

3. Usefulness of Heterosis Resulting from Interbreed Matings.

These studies are concerned with the theoretical and practical aspects of heterosis resulting from interbreed matings. Projects are in progress at Beltsville and cooperatively with the Illinois and Indiana Agricultural Experiment Stations. The cooperating projects contribute to the North Central Regional Dairy Cattle Breeding Project. Most of the semen services are supplied through cooperation of the National Association of Artificial Breeders.

In both the Illinois and Indiana projects the viability of crossbreds has been significantly greater than that of the purebreds. In the Illinois project the number of first and second generation purebreds leaving the herd for natural causes before producing a calf averaged 20.1% versus 8.3% for the Holstein-Guernsey crossbreds. There was no difference between first generation purebreds and crossbreds in services per conception, interval from first service to conception, interval from calving to first heat and interval from calving to first service.

Analysis of production records in the Indiana experiment showed that breed of dam, breed of sire and the interaction of breed of sire by breed of dam had a significant effect on total milk yield. This indicates that crossbreeding has a significant effect on total milk production. Sire within breed also had a significant effect on total milk production but the effect of dam was not significant. Preliminary studies of persistency of milk production in this project indicates persistency was more related to the level of production than system of breeding.

A preliminary analysis of daily gains and feed efficiency of purebreds (Red Danes, Red Polls and Milking Shorthorns) and two- and three-breed crossbred steers in the Indiana project indicated that three-breed crosses grew the fastest and utilized feed most efficiently. The average daily gains were 2.02, 2.12 and 2.22 pounds for purebreds, two-breeds and three-breeds steers, respectively. In a study of feed usage by the steers for daily gain and efficiency values in successive two week periods starting at 500 pounds, total feed consumption reached

a peak at about 16 weeks past the 500 pounds or at a weight of about 750 pounds, but average daily gain and gross efficiency declined after four weeks.

At Beltsville an analysis of the performance of the foundation Ayrshire, Brown Swiss and Holstein cattle in the crossbreeding study showed that persistency of milk production of the Ayrshires and Holsteins was similar and the same was true for body weight gain and pounds of FCM produced per therm of estimated net energy consumed. The Brown Swiss were significantly higher in persistency and body weight gain but significantly lower in gross efficiency. Studies of the rate of milking on the foundation cows between the second and eighth month of first lactation showed that the best estimate of the characteristic rate of milk flow can be obtained between the 90th and 120th day of lactation. Repeatability estimates for rate of milk flow (lb./min.) was high (.78) while that for average stripping time and percent of yield in stripping was considerably lower (0.48 - 0.49). The Brown Swiss were slightly lower in rate of milking and had significantly higher stripping time and percent of yield in stripping. Thus far, the average body weights at birth, 6, 12, 18 and 24 months of age for first generation crossbreds has been higher than for the average of all purebreds, but differences were not significant except at 12 months. The crossbreds have also exceeded the purebreds in depth and circumference of forechest, but slightly less in body length. (AH g2-23)

4. The influence of Parental Relationship on the Genetic Merit of Dairy Cows and Sires.

This research was undertaken to determine the relative merits of line-breeding, outcrossing and crossbreeding using progeny tested bulls of high merit as service sires. Mating plans were continued for the foundation cows and for first generation animals in each of the various mating systems. The foundation cows completed 104 lactations which averaged 15,939 pounds of milk, and 651 pounds of butterfat (2X, 305 days, M. E.).

Body measurements were taken on the females in each mating system at 6, 12, and 16 months of age and 90 days post partum. At 6 months of age 138 females were measured. Significant differences occurred between the group in depth and circumference of forechest and depth and circumference of paunch. The line-breds and Brown Swiss-Holstein (SXH) crosses were smaller than either the outcrosses or the Ayrshire-Holstein (A X H) crosses in these measurements. At 12 months of age 113 females were measured. Significant differences occurred among the groups in all measurements except depth and circumference of forechest. The S X H crosses were heavier and showed more length from withers to pins and withers to hips than the other groups. The A X H crosses were lighter and showed less height at the withers than the other groups. The line-breds were smaller than any of the groups in

circumference of the paunch. At 16 months of age 95 females were measured. Significant differences occurred among the groups in body weight, height at withers, length from withers to pins and depth of paunch. The S X H crosses were heavier than any of the other groups, followed by the outcrosses, line-breds, and the A X H crosses. The S X H were larger in all categories except depth of forechest and paunch and circumference of paunch. At 90 days post partum a total of 25 females were measured. There were significant differences among the groups in body weight, height at withers, length from withers to pins and length from withers to hips. It would appear from these results that as age advances the S X H crosses are heavier, taller, and longer than the other breed groups. The A X H crosses are not as heavy as the line-bred at 12 and 16 months of age, but are considerably larger in circumference of paunch. However, at 90 days post partum the A X H crosses are heavier than the line-breds.

Heifers from each mating system were placed on a standardized ration of free-choice alfalfa hay and 3 pounds of grain per day from 12 to 16 months of age. Feed efficiency rate of gain, total gain and hay consumption studies were made on 90 heifers. The only significant differences found between the mating system groups were in hay consumption. The outbred group exceeded all other groups. Significant differences occurred between sires within mating system group in rate of gain and total gain. Average daily rate of gain for the 90 heifers was 1.69 pounds and they gained a total of 202 pounds during the 4-month period. These results indicate that the variation between sires is more important and larger than the variation between mating system groups. (AH g2-24)

5. The Use of Progeny Tested Sires and Sons of Progeny Tested Sires.

A study was made to estimate the effects of culling out daughters from cows of low production capacity. The data were analyzed to determine the results of discarding daughters of all cows that produced less than 425 pounds of butterfat. Culling all daughters of these cows and the consequent exclusion of their descendants removed from the analysis 176 cows that averaged 661 pounds of butterfat. The 215 cows that were not excluded because of culling averaged 651 pounds of butterfat. These results show the ineffectiveness of heifer selection based on the low level of the dams' production. Usually in two generations, when good production proven sires were used, the progeny of low producing cows were about equal in ability to those of the rest of the group.

A study was made to estimate the relationship between production of a cow in her first lactation and the length of time she stayed in the herd. Data were obtained from 79 herds that had used Beltsville bred bulls. Results of within sire regression studies for age at disposal

and milk and butterfat production during first lactation were .024 month and .071 month, respectively. These results indicate no conflict between early maturity (high production) and length of life. They also suggest some success in keeping the higher producing animals in the herd.

The herds within each group were divided into low, medium and high levels of milk production to determine whether the level of production in the herd had any influence on the rate of culling the 1st lactation animals. Regressions of age at disposal on milk production were computed for each level of production within each group. The only significant differences found between the regressions were in the State and county institution herds. The highest regression was in the lowest producing group (.031).

A study was made to determine the effectiveness of using the contemporary comparison as compared to the daughter-dam comparisons in sire evaluation. Ten sires with a total of 324 daughters in one herd were used for the study. Records were adjusted for maturity and also for year changes in environment by a maximum likelihood technique (M.L.). Correlations were computed between differences of daughter-dam and daughter-contemporary for both fat and milk using ME records. These correlations were 0.70 and 0.64, respectively. When M. L. records were used the correlation increased to 0.89 and 0.92, respectively. These results indicate that when yearly fluctuations are removed by statistical measures, the differences between daughters and dams rank sires much the same as the differences between daughters and contemporaries. If it can be assumed that the M.L. records are an accurate measure of a cow's producing ability under a given environment, then using the contemporary comparison rather than the daughter-dam comparison is the best way to evaluate bulls. Correlations between daughter-contemporary difference ME and daughter-contemporary difference ME-ML were 0.96 for fat and 0.97 for milk. These high relationships are expected because records are made during the same environmental period.

A study of "Nicking" was made in three cooperator herds that had previously used a series of Beltsville bred bulls. Daughters of each sire were subgrouped according to their maternal grandsire. The response by daughters of the same sire out of dams from different lines of breeding could be studied by analyzing the means of the grandsire classes. Differential response would be an indication of "Nicking" or specific combining ability. A total of 13 sires and 38 grandsire groups were studied. In one herd significant differences existed between grandsire groups. When these data were adjusted for the depressing effects of inbreeding and year changes, the differences between grandsire groups disappeared. The other two herds did not show any evidence of nicking. These results are not surprising in this type of analysis. Any response would have to be very marked to be detected.

A study was made to determine the effects of inbreeding in different lactations of the same cow. One hundred eleven cows, each having 4 or more lactations, were used. They were by six different sires. Intra sire regressions of pounds milk per 1% inbreeding of the cow were: -105, -42, -18, -26, and -48 for 1st, 2nd, 3rd, 4th and average records, respectively. Corresponding regressions of pounds fat were: -3.6, -1.1, -1.3, -0.9 and -1.7. The only significant reduction in production due to inbreeding occurred in the first lactation. The other regressions were not significant. The regression coefficients for the individual sires varied within lactations but the differences were not statistically significant. (AH g2-25)

6. Genetic Methods for Developing Adaptability.

These investigations are to evaluate the effectiveness of certain genetic methods for improving dairy cattle adaptability to hot conditions through: (a) introduction of adaptability characteristics; (b) selection within existing breeds for further adaptability; and (c) hybridization of existing breeds by continuous crossing or developing new strains from a crossbred foundation. This work is in cooperation with the Georgia, Louisiana and Texas Agricultural Experiment Stations. Most of the semen services are supplied through the cooperation of the National Association of Artificial Breeders. All of the studies are contributing projects to the Southern Regional Dairy Cattle Breeding Project, S-49. The PL-480 grant fund cooperative project in Colombia contributes to this work.

(a) Introduction of adaptability by crossing European breeds with Red Sindhi and Brahma cattle.

Analysis of milk and fat production data from the experiments of crossing Red Sindhi with Jerseys and Holsteins have been completed and published. The first lactation average of the F_1 Red Sindhi-Brown Swiss crosses was 3,286 pounds of milk and 160 pounds of fat. This was 42% less milk and 30% less fat than their purebred Brown Swiss herd-mates, and 49% less milk and 35% less fat than their purebred maternal half-sisters. The first lactation average of the $3/4$ Brown Swiss crosses was 5,047 pounds of milk and 225 pounds of fat which was 10% less milk and 2% less fat than their purebred herdmates. The Brown Swiss crosses were like the other crosses in that production was highly variable, persistency poor and many were highly temperamental. As with the Red Sindhi-Jersey and Red Sindhi-Holstein crossing, the Brown Swiss crossing has been discontinued.

At Texas A & M, all the $3/4$ Jersey- $1/4$ Brahma crosses have calved one or more times. Although the average first lactation production of this group was 37% higher than for the F_1 crosses, the proportion that could not be milked and the variability in production was similar

to that for the F₁ crosses. This same pattern is appearing in the 7/8 Jersey crosses. This project has now shifted to inter se mating of crossbreds. Although too few in number to warrant conclusions, the level of production and docility appear better than in the fractional crosses.

(b) Selection within the existing breeds.

Genetic and environmental aspects of milk and fat production in the Louisiana State University Holstein herd have been studied. Heritability estimates for milk and fat yield were derived from the first lactation records of 222 daughter-dam pairs representing 21 sires. The heritability for both milk and fat was 0.24 and the genetic correlation between milk and fat yields was .882. These estimates are in good agreement with those reported by other workers. Efficiency of feed utilization was calculated from 357 records of 151 daughters of 17 Holstein sires. The coefficient of efficiency of these sire groups ranged from 23.3 to 28.4%. The heritability and repeatability estimates obtained from the paternal half-sib correlation analysis were .366 and .516, respectively. Although the heritability for feed utilization contains a sizeable sampling error, it would appear that feed efficiency is as heritable as either milk or fat production. There were no significant season of calving differences for milk, fat or feed efficiency. The heritability estimates obtained will be used in computing the selection indices for the cows in the breeding project.

The planned base population of 80 Jersey cows has been established in the Tifton, Georgia, herd. Twelve essentially unrelated Jersey sires have been used in establishing this base. The selection program aimed at improving volume and composition of milk has been initiated.

(c) Hybridization of existing breeds by continuous crossing or developing a new strain from a crossbred foundation.

In the crossbreeding study at Reidsville, Georgia, with Brown Swiss, Holsteins and Jerseys, the Holstein-Jersey crosses have produced above the "expected" (mean of the parents), whereas the Brown Swiss-Jersey crosses have been lower. The production of the Brown Swiss-Jersey crosses has been more variable than for the other crosses.

In a preliminary study of the performance of crossbreds versus purebred Holstein at Jeanerette, Louisiana, the average 305 day milk yield of the crosses was 650 pounds less than for the purebred Holsteins but the average butterfat content (3.48%) and solids-not-fat content (8.15%) of the Holsteins was less than desired by the local milk market. The breeding efficiency of the purebred Holsteins was also lower than for the crossbreds. During the past year the herd has been changed over to essentially a dry lot feeding program and it appears that the level

of production as well as milk composition of the purebred Holsteins is more responsive to this change than the crossbreds. Thus far the crossbreds in this herd by Holstein sires have produced better than the crosses by Brown Swiss sires. (AH g4-2, S5 AH-1)

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AREA NO. 6 - DAIRY CATTLE - PHYSIOLOGY

Problem. Fundamental physiological research is required as a basis for improving lactational and reproductive performance of dairy cattle. Breeding failure is a major reason for the disposal of cattle from our dairy herds. There is a lack of basic information on the physiological action of hormones in controlling reproductive activity, correcting reproductive abnormalities and stimulating lactation. Research on physiological processes related to growth and development, nutritional requirements and to heat tolerance of dairy cattle is required.

USDA PROGRAM

This is a continuing program, almost entirely on basic research, conducted by physiologists and biochemists. The program is designed to elucidate the reproductive and lactational physiology of cattle utilizing physiological and biochemical techniques and to determine physiological mechanisms related to heat tolerance. The work is in progress at Beltsville, Maryland, and cooperatively at the Wisconsin, New York, Massachusetts, Texas, Louisiana, and Georgia Agricultural Experiment Stations. It is coordinated with the NE-41, W-49, and S-49 regional projects.

The Federal scientific effort devoted to the research in this area totals 8.6 professional man-years. Of this number, 2.7 are devoted to the physiology of reproduction, 4.0 to the physiology of milk secretion, 1.0 to the physiology of growth and development, 0.6 to environmental physiology, and 0.3 to program leadership.

A grant with the Veterinary School of the University of Sao Paulo, Brazil, provides for research on the anatomical and physiological characteristics affecting heat production and heat loss of Zebu, European and Zebu-European crossbred cattle and the nature and method of controlling the inheritance. Its duration is for five years, 1961-1966, and involves PL-480 funds with a \$63,293 equivalent in Brazilian Cruzeiros. (Pertains to Area 5 also)

Another grant with the Indian Veterinary Research Institute, Izatnagar, UP, India, supports studies on the physiology and genetics of characteristics influencing the adaptability of cattle and buffalo for dairy production. The duration of this work is five years, 1961-1965; it involves PL-480 funds with a \$195,624 equivalent in Indian rupees. (Pertains to Area 5 also)

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

The State experiment station scientific effort in this area totals 45.1 professional man-years divided among subheadings as follows: physiology of reproduction 26.6, physiology of milk secretion 10.0, environmental physiology 3.1, other physiology 5.4. A regional project on diseases affecting reproduction, NE-40, Pathology of Breeding Failures, is reported in Unit 2, Animal Disease and Parasite Research. Research on physiological aspects of infertility in cattle is coordinated through regional projects NE-41, Endocrine Factors Affecting Reproduction involving 9 States, and W-49, Physiological Mechanisms Affecting Fertility, involving 10 Western States.

Industrial research amounting to approximately 25 professional man-years is conducted primarily by the pharmaceutical companies and to some extent by feed manufacturers. Most of the work is in the field on the response of dairy cattle to hormones and antibiotics.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Physiology of Reproduction

A portion of this work is reported in Area 1, Animal Biology, because it has application to classes of livestock other than dairy.

1. The Corpus Luteum.

a. The Corpus Luteum of the Estrual Cycle.

The mechanism responsible for the maintenance of pregnancy involves the maintenance of the corpus luteum which normally develops during each estrous cycle. Determinations of progesterone, cholesterol, DNA, RNA and percent functional luteal cells were made at 2-day intervals throughout the estrous cycle in order to obtain an estimate of the physiological activity of this CL. CL weights were similar in the 7-17-day period and were higher than the 3-5-day period, indicating that the major increase in weight had occurred by day 17. A decrease in CL weight occurred from the 7-17-day period to day 19. Percent dry weight increased from 17.8% at day 7 to 21.2% at day 17 and was 22.5% at day 19. Total progestogen (Progesterone + 4-pregnene-20b-ol-3-one) per gram of fresh luteal tissue increased from 26.9 ug at day 7 to 50.7 at day 15 and then dropped to 9.1 at day 17. An apparent increase to 19.1 at day 19 was noted but this value (6 CL range 4-39 $\mu\text{g/g}$) was much more variable. This decrease in CL progesterone in the 15-17-day period might indicate that this is the stage when the mechanism responsible for maintenance of CL during pregnancy becomes necessary. Total free cholesterol content (precursor for progesterone synthesis) increased to day 15 and then decreased with CL regression. If free cholesterol is expressed as a ratio of free cholesterol/DNA the differences are

not significant indicating that free cholesterol may be primarily a function of cell numbers. The RNA/DNA ratio, a measure of functional activity per cell, decreased from day 7 to day 17 with a significant drop occurring after day 13. This agreed well with changes in percent functional luteal cells as estimated by the Foley-Greenstein classification. (AH h5-6, cooperative with the University of Wisconsin)

b. Variations in Some Biochemical and Histological Characteristics of Bovine Corpora Lutea During Early Pregnancy.

Two experiments involving 40 heifers were used to study the level of function of the corpus luteum during early pregnancy. Experiment 1 was a comparison of day 14 of the estrual cycle and day 14, 28, and 42 of pregnancy. Experiment 2 compared day 18, 23, and 28 of pregnancy. Progesterone and total progestogen were lower, $P < 0.01$, on day 28 and day 42 of pregnancy than on day 14. A significant, $P < 0.01$, negative regression of progesterone and total progestogen content on day of pregnancy up to day 28 was found, -6.07 and -6.32 micrograms, respectively. These regressions appeared to be linear. The level of 4-pregnene-20B-ol-one did not appear to vary with stage of pregnancy. Free cholesterol concentration increased significantly between day 14 and 28 but tended to return toward the day 14 level by day 42. The regression of free cholesterol between day 14 and 28 of pregnancy was 35.6 micrograms per gram per day, $P < 0.01$, and appeared to be linear. Mean concentrations of DNA were not different but RNA decreased with increasing length of gestation. A decreased percentage of functional cells was apparent histologically at day 23 of pregnancy and at later stages as compared to day 14 or 18 of pregnancy. The latter named stages in turn had fewer functional cells than the unbred heifers of day 14 of the estrual cycle. (AH h5-6, cooperative with the University of Wisconsin)

c. Progesterone Content of Corpora Lutea and Reproductive Organ Weights in Normal and Pregnant Cattle.

Statistical study of organ weights in more than 80 head of pregnant cattle has shown, as expected, that ovarian weight increases appreciably with age of animal. A similar, but far less pronounced change occurs in corpus luteum size.

A similar study of corpus luteum weight (uncorrected for animal size or weight) in 40 normal cattle at five stages of the estrous cycle showed the expected increase in size to mid-cycle (mean 5.3 gm. at day 12) followed by a decrease to a mean of 3.18 gm. at 18-19 days.

Data on the progestin content (progesterone and 20b-hydroxyprogesterone) of the corpus luteum from a sample of six normal cattle each at 6, 12,

and 18 days of the estrous cycle showed, for the two components, respectively, 80 and 2.6, 126 and 51, and 75 and 23 micrograms. Corresponding concentrations in micrograms per gram of tissue were 22.6 and 0.7, and 23.4 and 9.0, and 16.7 and 5.3. To the extent that content reflects secretion rate, progesterone production rises and falls with corpus luteum growth and regression. The hydroxyprogesterone component, however, is virtually absent in early growth stages (3% of total progestins) but becomes a major fraction of the total at later stages (28 and 24%). In a sample of corpora from pregnant cattle, progesterone and 20 β -hydroxyprogesterone averaged 21.5 and 16.0 micrograms per gram, the latter component now amounting to 43% of total progestins. The biological potency of hydroxyprogesterone in the cow is being assayed through its comparative effectiveness in blocking heat and ovulation. (AH h5-4, cooperative with the University of Massachusetts)

d. Effects of Experimental Endocrine Treatment of Animals on the Activity of Their Corpora Lutea.

Attempts have been made to modify CL activity of the cow using several substances which may be involved in the function and maintenance of this gland. The progestogen content (progesterone and 4-pregnene-20 β -ol-3-one) of the corpus luteum was used as the measure of luteal activity.

Oxytocin. Control CL were removed from 10 heifers and after a recovery cycle, they were injected on days 12 and 13 with oxytocin. The CL removed 24 hours after the last injection showed a significant increase in progestogen (271 μ g (control) vs 421 μ g (oxytocin treated) $P < 0.01$).

Unfractionated pituitary extract. Control CL were removed from 8 heifers on day 14 and after a recovery cycle, they were injected on day 12 or 14 with an unfractionated pituitary extract. CL were removed 48 hours or 6 hours later and showed an increase in progestogen content (314 μ g) when compared to control CL (246 μ g).

Luteinizing hormone (LH). Control CL were removed from 5 heifers on day 14 of the estrous cycle and following a recovery cycle, they were treated with LH on day 11, 12, or 13. CL were removed on day 14 and showed a decrease in progestogen content from 268 μ g to 185 μ g. Three 8-month-pregnant animals showed no change in progestogen content of their CL following treatment. Lactogenic Hormone (ovine) and Human Chorionic Gonadotrophin (HCG) were also administered in a similar fashion to cycling heifers and showed no effects upon the amounts of luteal progestogen. (AH h5-6, cooperative with the University of Wisconsin)

2. Embryo Survival in Dairy Cattle.

Death of embryos during early stages of development is recognized as the most frequent cause of repeat services to dairy cattle. It had not been determined previously whether pregnancies could be maintained in ovariectomized cattle during the first few weeks of embryonic growth. Pregnancies were maintained by injection of exogenous hormones in 13 of 14 cattle ovariectomized 5 to 7 days postbreeding. Two of the embryos died at approximately 50 days postbreeding; 11 others were normal when the cows were killed 35 to 60 days postbreeding. The pregnancies were maintained with progesterone and estrone or with progesterone alone. Embryo survival was compared in intact and ovariectomized cows of low fertility (repeat-breeders). Embryos survived in 3 of 19 intact controls (15%) and in 3 of 14 cows ovariectomized 5-7 days postbreeding (21%). Uteri of 4 ovariectomized cows contained degenerate embryos 35 days postbreeding. It appears that in ovariectomized repeat-breeder cows the majority of embryos cannot survive past a certain age (approximately 18-20 days) even though hormone administration is sufficient to maintain pregnancies in a high percentage of first-service animals. The results to date fail to suggest that aberrant ovarian hormone secretion causes embryonic death in repeat-breeder cattle. Results support the hypothesis that embryonic death occurs in cattle before the corpus luteum begins to regress; the reverse possibility is thus not supported. (AH h5-3)

3. Repeat Breeders.

To explore causes of repeat breedings in the Louisiana State University herd, a study was made to characterize the biochemical and physiological properties of cervical uterine fluids in both normal and repeat breeding cows and heifers. There was considerable variation in the pH, Na, K, Ca, Mg, inorganic phosphate, reducing sugars and protein content of the fluids of cows, irrespective of their reproductive background. However, the fluids from the repeat breeders tended to have a higher concentration of electrolytes. Chromatographic studies indicated the presence of complex polysaccharides in both cervical and luminal fluids. There was no evidence of simple sugar such as glucose and fructose in these fluids. (AH g4-1)

4. Experimental Alteration of the Estrous Cycle in Cattle.

This work is part of a study to determine the factors which control ovulation and regulate the estrous cycle in cattle. Previous work had shown that injection of oxytocin following ovulation shortens the following estrous cycle length from the normal 22-day interval to approximately 8-10 days. The mechanism of action of this posterior pituitary principle is believed to be through regulation of the

activity of the anterior pituitary gland which produces the gonadotrophic hormones which in turn control reproductive function. In the present study oxytocin injection was used as an experimental tool to study the effect of luteal function on embryo development and survival. Seventy-nine oxytocin-treated and untreated control heifers were killed 15 days after insemination and their embryos, ovaries, reproductive tracts and endocrine glands studied. Seventy-four percent of the untreated inseminated heifers had normal embryos at 15 days and this recovery was significantly ($P < .01$) reduced to 42% in the oxytocin-treated heifers. Thirty-five percent of the oxytocin treated heifers returned to estrus before 15 days.

The progesterone content of the **corpora** lutea of the treated heifers that returned to estrus and had no embryos was lowest; those treated heifers that did not return to estrus but had no embryos had a slightly higher progesterone content in their corpora lutea, but the level was significantly below that of the untreated heifers. Oxytocin treated heifers with normal embryos had as much progesterone in their corpora lutea as the untreated control heifers. The data suggest that the response to oxytocin is an "all or none" phenomenon which once initiated, results in marked inhibition of luteal development and progesterone production and in embryonic death. If the response is not evoked, the corpus luteum develops normally, and produces a normal amount of progesterone. The data also suggest that in some cases a low level of progesterone production is capable of preventing a heifer from returning to estrus, but is not capable of maintaining a normal embryo.

Two new commercial progestational compounds, Provera and Enovid, were fed to cows to regulate the estrous cycle. Provera was fed to 32 beef cattle. Although the compound was effective in regulating the cycle lengths, the percentage conceiving after treatment was low, about 25%. Enovid was not effective in inhibiting estrus since 11 of 18 cows fed the compound came into estrus during the 20-day feeding period.

These studies have contributed to an understanding of the nature of the early embryo mortality problem in cattle. The data show that inhibition of luteal function, which can be caused by a variety of treatments, can cause embryo death prior to the 15th day after breeding, and that cows with normal embryos at this stage of pregnancy are likely to be producing normal amounts of progesterone. The data also suggest that factors which cause the development of cystic corpora lutea are also likely to cause embryo mortality. (AH h5-3, cooperative with the Cornell University)

Experiments were continued on the synchronization of estrus. Provera was found to be effective in inhibiting estrus and ovulation but

although the compound was effective in regulating cycle length, fertility was low. The percentage conceiving after this treatment was only 25% in trials on beef cattle. Trials conducted this year with dairy cattle (Holstein heifers) resulted in good synchronization and 56% of the heifers conceived when bred artificially at the synchronized estrus. An attempt was made to reduce the hormone feeding period (20 days) and good synchronization was obtained with a 15-day feeding period and 60% conception rate, again in Holstein heifers. Experiments involving Hereford heifers showed essentially similar results to those obtained previously, good synchronization but low fertility. (AH h5-3, cooperative with Cornell University)

5. Tubo-Uterine Junction Opening and Closing in Cattle.

An experiment is in progress to determine whether the tubo-uterine junction of the cow undergoes a cyclic opening and closing. The left oviduct of heifers was ligated at the ovarian end at about the time of ovulation. The animals were killed at various times after operation, a hemostat being placed just anterior to the junction prior to removal of the reproductive tract from the body. Presence or absence of gross distension of the ligated oviduct is taken as evidence of patency of the tubo-uterine junction. Six heifers showed distension, 2 slight distension and 3 no distension in the 3-4 day period following estrus. One animal at 6 days post estrus showed no distension. These data suggest a decreased resistance on the part of the tubo-uterine junction to flow of oviduct secretion about 72 hours after ovulation. This agrees well with the time when the ovum normally enters the uterus of the cow.

The influence of ovarian hormones on this phenomenon is also under study. Two heifers treated with 25 mg. estradiol-17b daily for 5 days beginning at ovulation still had distended oviducts when killed 161 and 167 hours later. Further studies are planned in which progesterone as well as estrogen in more physiological doses will be utilized. Histological examination of the tubo-uterine junction is underway and wax-plate reconstructions are being made in an attempt to find a physiological or morphological change which can explain the results being obtained.

Previous studies indicated a decreased resistance on the part of the tubo-uterine junction to flow of oviduct secretions about 72 hours after ovulation. The apparent block prior to this time has been studied during this year utilizing in vitro insufflation to measure the pressure required to force air through the oviduct and into the uterus. Removal of the tubo-uterine junction itself produced no appreciable pressure drop. Progressive removal of sections of the isthmus permitted gas to be passed through the tube at greatly reduced pressures. Thus the blocking mechanism in the cow appears to reside

in the lower 4-5 CM of the isthmus, rather than the junction as in some other animals. Experiments are now being conducted in which both circular and longitudinal muscular activity are being recorded, as well as pressure required to force air through the oviduct. Pharmacological and hormonal agents will be tested in vivo and in vitro for their effect on the blocking mechanism. Sperm transport through the junction is also being studied. Dead spermatozoa from the bull, rabbit, rat and human can be transported through the tubo-uterine junction in the rat, with cells appearing in the oviduct within a few hours after uterine insemination. (AH h5-4, cooperative with the University of Massachusetts)

B. Physiology of Milk Secretion

The Relationship of Histamine to Antibodies in Cow's Milk.

Antibodies against antigens occur in milk when the antigens are injected by intramammary infusion, subcutaneously or intramuscularly. The antibody-containing milk has been proposed as having medical usefulness in conferring immunity upon humans or animals ingesting this milk and the milk has been termed "protective" milk. In order to confer immunity, absorption of ingested antibodies must take place through the digestive tract and the antibodies must then be transferred to the circulation. The ability of untreated calves and calves treated with Escherichia coli "protective" milk to survive E. coli injections was studied. Histamine is released in antigen-antibody reactions and was, therefore, followed routinely in blood samples during the production of the "protective" milk and during the survival tests for the protective ability of the E. coli milk. Blood histamine concentration was 0.15 µg histamine per ml whole blood in 8 cows after intramammary infusions of E. coli (75 samples, range 0.1 to 0.3). No definite trends in blood histamine concentrations were evident. Histamine concentration was found to increase in calf blood after birth, being 0.13 µg/ml on the day of birth and 0.21 one day later (9 calves). Calves exhibited a higher blood level than adult animals, histamine concentration being 0.18 µg per ml blood (13 calves, 72 samples). When challenged with sublethal intravenous doses of E. coli, control calves (not fed "protective" milk) exhibited a rise in blood histamine concentrations 1, 2, and 3 days after injection (3 trials). When given orally, there was little change in blood histamine content. In 7 paired experiments utilizing large lethal doses of E. coli, there was little change in blood histamine concentration during the survival period of several hours in either group (control or "protected"). (AH g1-7, h5-1)

C. Physiology of Growth and Development

1. Characterization of Vaginal Temperature Patterns in Cattle.

Previously reported work demonstrated that body temperature changes are indicators of the functional status of the corpus luteum. The effect of progesterone on body temperature had been demonstrated in normally cycling, ovariectomized and pregnant cows. During these studies continuous recordings of vaginal temperatures were employed and a diurnal pattern of temperature rhythmicity had been noted. This rhythm has been characterized during the past year in (1) normally cycling cows, (2) ovariectomized cows, (3) pregnant cows and (4) young heifer calves. Sixty-seven percent of the diurnal temperature rhythms describes a diphasic pattern whereas 23% were found to be monophasic and 7% polyphasic. Horizontal linear patterns, i.e., aperiodic, were observed in 3% of the curves obtained. In general, temperatures were elevated in the mid-morning and afternoon and were low during the evening and early morning hours. Calves showed the highest mean temperatures (101.6° F.), while the ovariectomized group showed the lowest mean temperatures (100.6° F.) of the animals studied. These studies represent the first complete characterization of diurnal temperature patterns in cattle. The utility of using single daily temperature measurements, rather than continuous recordings, as an indicator of reproductive function appears rather limited for practical field use. (AH h5-3)

2. Body Composition During Growth.

Chemical and physiological measurements of body constituents during growth is a prerequisite for an evaluation of the efficiency of the conversion of the energy value of feeds into muscle tissue. Characterization of tissue and body composition would make it possible to accurately determine whether a body weight gain is in fat, muscle or water and the relative proportion of each. This study was initiated during the past year to determine changes in body composition, more particularly, the extracellular water compartment, by means of distribution of an exogenous material during growth in male and female dairy cattle. Estimates of the size of the extracellular body water compartment of growing calves were determined by observing the distribution of sodium thiocyanate. One-hundred and forty-six estimates of thiocyanate space were made using 76 calves. Data were collected on heifer and bull calves up to 800 lbs. of body weight. The results show that extracellular water, as estimated by thiocyanate space, decreased rapidly in growing calves from about 48% of body weight at birth to about 30% at 1 year. This decrease occurred earlier in heifers than in bulls--during the first 4 months in heifers and in the 5- to 7-month period in bulls. The thiocyanate space of young bulls tended to be higher than in heifers of the same weight. In bulls the pronounced

decline in thiocyanate space coincided with the probable time of onset of sexual maturation. (AH h5-3)

3. Influence of Vitamin A Deficiency on Cerebrospinal Fluid.

Work was begun in 1960 to study the mechanism whereby the cerebrospinal fluid (CSF) pressure is increased in vitamin A deficiency in calves. This research has involved three distinct phases (1) the influx of thiocyanate (SCN) ion from the blood to the CSF in normal and vitamin A deficient calves, (2) the efflux or rate of disappearance of SCN from the CSF, and (3) direct measurements of the rate of replacement and absorption of CSF. The results of the first phase of the work reported in 1960 indicated that SCN moves from the bloodstream to the CSF at rates quantitatively similar in normal and deficient calves. The rate of disappearance of SCN from the CSF (phase 2) was found to be slower in the deficient calves, thereby indicating a slower rate of absorption. When the rate of replacement of CSF was studied directly by removing the fluid and measuring the time necessary for replacement (phase 3), it was found that vitamin A deficient calves replaced the fluid 2 - 2.5 times more rapidly than normal animals. Estimates of absorption capacity, however, indicated even larger differences, suggesting that differences in absorption represent a larger factor than formation of fluid. These results of phase 3 thus show a considerable degree of agreement with the slower rate of disappearance of SCN observed in vitamin A deficient calves. Underabsorption, therefore, appears to be a greater factor than overproduction in the etiology of the CSF pressure increase in vitamin A deficiency. (This work is supplementary to work under AH h1-3).

D. Environmental Physiology

These studies deal with the determination of the anatomical and physiological characteristics affecting heat production and heat loss of dairy cattle under hot conditions and the nature of the inheritance of these characteristics.

1. Effect of High Environmental Temperatures on Reproductive Performance of Heifers.

At Beltsville, in cooperation with the Beef Cattle Research Branch, a series of studies have been conducted to determine the effect of prolonged heat stress on reproductive performance and certain physiological responses of two-year-old, virgin, Angus, Shorthorn, and Hereford heifers. The initial study was made with six pairs of Shorthorn heifers. One of each pair was kept in a psychrometric chamber commencing in December of 1959 for a period of 29 weeks at 90° F. and 60% relative humidity. Five of the animals, under heat stress, ceased to cycle after five weeks while the control group continued normal cycling. In the noncycling heifers follicle formation

continued without maturation and ovulation. By the 21st week, the heat group reestablished normal estrous cycles and were bred. Pregnancy was maintained in this group for 66 days under experimental conditions.

In the second study six heifers were kept in the psychrometric chamber for 14 weeks at 90° F. beginning in September 1960 and two other groups were kept in barns under near ambient temperature conditions, one group under artificial light and the other with natural. Although the rectal temperatures of the chamber group rose higher than the similarly treated animals in the previous winter study, only one animal ceased to cycle during the period. In this case, temperament was probably more responsible than the high temperature. During the test, the average cycle length was 20.3, 20.8, and 21.3 days for the control, heat and light groups, respectively. This was no change from the intervals recorded for the three months prior to the experiment.

To further test the hypothesis that cessation of the estrous cycle is associated with the degree of stress, six of the heifers from the second study were held over and allowed to become conditioned to summer conditions in 1961. These animals were placed in the chamber in mid-July for 8 weeks at 100° F. Body temperatures rose to high levels (average 105.4° F.) in the first week and this time the estrous cycle was disrupted indicating a relationship to level of stress. The fourth study was made at 90° F. in late 1961 with Hereford heifers. The results were similar to that for the Angus heifers in the previous year. The findings thus far indicate that the stage of adaptation, that is whether the animals are acclimated to winter or summer conditions, is quite important in their response to heat stress and the resulting effect on the estrous cycle. Under field conditions, this means a sudden onset of hot weather in the spring is more likely to effect reproductive performance than similar temperature conditions later in the summer. (AH g4-1) (Also reported in Area 3)

2. Effect of High Temperatures on the Hair Coat of Cattle.

To determine the influence of environmental temperature on hair coat of cattle, studies were made under both ambient conditions in various seasons of the year and constant 90° F. temperature for periods of 12-30 weeks. The photoperiod in the chamber corresponded to that normal for the season and a combination of fluorescent and incandescent lights were used to provide the foot candles of light corresponding to the 9:00 a.m.-3:00 p.m. average in an open barn. Milking Shorthorn heifers subjected to the 90° F. temperature in December shed most of their winter coat by the fifth week while the coat of the controls continued to grow. The heat group shed a second time at about 15 weeks. The initial shedding reduced the coat to that normally expected in summer for Shorthorns (average depth .55 inches). After the second shedding, coat depth was reduced to .20 inches. Since

the artificial lighting may have been a factor in the results, a third group was added in the second trial, that of ambient conditions with artificial light corresponding to that of the chamber. The second study was for 14 weeks from September-December. The hair coat of the artificial light-ambient temperature group grew slightly slower than the ambient controls, but by the 11th week the means for the ambient groups were nearly the same. The hair coat of the heat group continued to grow for the first four weeks, but remained very stable thereafter. There was evidence of thinning of the hair coat in the heat group as the test progressed, but not a complete shedding as occurred in the previous winter group. At the close of the 14-week test period, the control group was subjected to the 90° F. temperature. After three weeks, all animals had shed 50% or more of their winter hair coat. Present results indicate high body and/or ambient temperatures play an important role in the type of hair coat that cattle have at a given time and depth of hair coat and rate of shedding are important in the animal's ability to adjust to high ambient temperatures. (AH g4-1)

3. Blood Constituents Related to Environmental Changes.

This work is part of a study concerning the relationships between blood levels of ketones and short-chain fatty acids on milk fat production. Total blood ketone bodies in six cows were determined at 10-day intervals over a period of 18 months. There was considerable rise in ketone bodies during fall and early winter and several smaller peaks occurred in spring and summer. These blood ketone changes were correlated with the air temperature for fall and winter seasons and with maximum water temperature for the spring and summer, providing circumstantial evidence for an influence of cold and heat stress on levels of blood ketone bodies. In late winter and late summer the effects of cold and heat, respectively, were minimal. Analysis of variance indicated that the largest factor was environmental. However, only 30% of the variation that could be attributed to environment was accounted for by temperature. There was a tendency for cows to be higher in ketone body concentration during the first 60 days of lactation, but this tendency was not consistent. The effect of both cold and heat stress was to increase blood ketone bodies. Correlations with minimum winter air temperatures on days previous to the taking of blood samples show that there is a lag of 2-3 days between temperature and level of ketone bodies. For warm weather periods, maximum water temperature taken in an open tank seemed to give better relationships with ketone body level than air temperature. A similar lag of 2-4 days exists between both temperature and response in level of ketone bodies. It would appear that the effect of cold on ketone body level begins when the air temperature drops below 35° F. The effects of heat are consistent with the view that air temperatures above 85° F. place stress on cows and this may be accentuated by high humidities. The lack of response in late winter and summer suggests that adaptation to extreme temperatures occurs. (AH h5-1)

To determine the relation of blood ketones, blood glucose and blood cell volume to changes in rectal temperature under heat stress, 12 mature, nonlactating Holstein cows were paired by weight and placed on experiment in October 1961. The cows were fed at 115% of maintenance and actual feed consumption recorded to investigate the effect of feed intake on the various physiological measurements. One animal of each pair was kept in a psychrometric chamber for alternating two-week periods at 90 and 70° F. with 60% relative humidity, while pairmates were kept under prevailing ambient temperatures (40-78° F.).

Blood cell volume was significantly lower in the chamber group and there was a significant difference between days within groups. The cell volume of the chamber group declined during the first week of each of the 90° F. periods then rose slightly the second week, while in the control group there was little similarity of patterns in the three test periods. Indications are that under constant environmental conditions, repeatability of response is high while under natural conditions, the interaction of environmental factors is such that responses are not predictable. Significant differences between cows indicate that each cow has her own particular range of blood cell volume.

Significant differences in blood ketone levels were found between periods within both groups and between days within the control group. Blood glucose levels were highly variable but only periods within groups were significantly different. It appeared under these experimental conditions, that heat stress had little effect on either blood ketone or blood glucose levels. However, it should be pointed out that the association between ketones and heat stress may be seasonal with little relationship being shown during the fall season.

There were significant negative correlations between rectal temperature and blood cell volume (-.24) and rectal temperature and blood ketone levels (-.28) in the chamber group. Data from four Angus heifers subjected to 100° F. and 60% relative humidity showed highly significant declines in blood cell volume (40.5 to 28.8%) and blood ketone (1.32 to 0.84 mg %) over a seven week trial, with correlations of (-.70) and (-.64), respectively, with rectal temperature. Rectal temperature and respiration rate was significantly correlated in both the chamber group (.68) and the control group (.37). Dry matter intake (24 hours prior to sampling for day 15) showed positive correlations with blood ketone levels, however, the relationship was significant only in the Holstein control group (.82). The correlation of dry matter intake and blood glucose levels was positive but significant only in the chamber group (.77). A possible explanation is that in the control group where there were no feed refusals, blood ketone levels were affected mainly by feed intake, while in the chamber group some animals

refused a large portion of their feed and fasting may have caused a rise in blood ketone levels. Blood glucose, like dry matter intake, was quite stable in the control group, while in the chamber group blood glucose decreased as dry matter intake declined. Correlations between dry matter intake and rectal temperature were not significant. Respiration rate and dry matter intake in the chamber group showed a significant negative correlation (-.72). From these studies it is evident that: (1) heat stress is associated with a decline in blood cell volume and under higher levels of stress this response is greater and there is less chance for recovery, (2) feed intake is associated with changes in blood ketones and glucose levels, while the relationship of heat stress on blood ketones independent of feed intake is not clear, and (3) high respiration rates may prevent normal feed consumption, due to the greater concern of the cow to breathe than eat. (AH g4-1)

4. Effect of Hot Conditions on the Physiological Responses of Dairy Heifers.

At Louisiana State University, 9 yearling heifers of Jersey, Holstein and Red Sindhi-Holstein (F_1) breeding were kept in a climatic control chamber under cool conditions for a 78-day period and then exposed to 90° F. daytime and 75° F. night temperatures for a 40-day period. Weight gains were reduced markedly during the first 20 days but gains returned to normal levels in the third and fourth 10-day periods. Reduction in rate of gain was associated with an increase in water consumption and decline in forage dry matter intake, but after adjustment to the heat, forage dry matter intake returned to nearly normal levels. Blood volumes were studied at the end of the cool and hot periods. There was no significant change in plasma volume, but there was a marked reduction in the red cell volume following exposure to the hot conditions. This change was associated with changes in respiratory activity. Rate of thyroxine utilization declined upon exposure to hot conditions, but plasma protein bound iodine increased. Therefore, no significant change in daily thyroxine utilization was evident. Oxygen consumption per $W^{.7}$ and digestibility of dry matter were higher at the end of exposure to hot conditions than at the end of the exposure to lower temperatures. None of the responses studied showed sufficient correlation with rate of gain to be considered as a satisfactory index of heat tolerance.

An additional study of thyroid and metabolic activity with yearling Holstein heifers was made for a 69-day period under cool and hot conditions. The mean plasma level of 17 hydroxycorticosterone increased from 1.7 micrograms % under cool conditions to 4.5 during heat exposure. A temporary eosinophilia occurred immediately upon exposing the animals to heat which was indicative of adrenal-cortical insufficiency. The eosinophilic condition rapidly disappeared and was

never followed by eosinopenia. Serum PBI and thyroxine utilization secretion rates were significantly lower under hot conditions. Weight gains were markedly reduced under the second 12 days of heat exposure. Rate of gain and dry matter intake were highly correlated. Respiration rate and body temperature showed significant adverse effects from heat exposure but were not highly correlated with rate of gain. Estimated heat production (kilocalories cwt .72/hr) was highly correlated with serum PBI and thyroxine secretion rates (mg/cwt/day). Measures of adrenocortical response were not significantly associated with any measure of thyroid activity. (AH g4-1)

5. Influence of Heat Stress on Rumen Volatile Fatty Acid Levels.

Two experiments have been conducted at Beltsville to study the effect of 90° F. temperature on rumen VFA levels; one with 12 mature, nonlactating Holstein, six of which were kept in a psychrometric chamber for 12 weeks of alternating 2-week periods of constant 70 and 90° F. temperatures with 60% relative humidity while pairmates were housed under prevailing ambient conditions (40-78° F.). In the second trial five Hereford heifers were kept at 90° F. for 12 weeks while the pairmates were housed under ambient conditions (36-56° F.). All animals were fed at 115% of maintenance requirements. Rumen samples were taken approximately five hours after morning feeding by stomach tube. VFA content was determined by column chromatography. The total fatty acid levels were only slightly lower in the chamber groups (Holstein 90.3 meq/lit and Hereford 100.6 meq/lit) than the control groups (93.7 and 106.6 meq/lit), but acetic acid portions were significantly lower in the chamber groups (Holsteins 59.8 and 62.8 and Herefords 52.9 and 61.2). Rectal temperature was correlated with total VFA levels in the Holstein (-.78) and Hereford (-.49) chamber groups. In the Hereford chamber group, total VFA levels were correlated with feed intake (.49) and water intake (.37). From present data, it is conceivable that heat stress, as measured by increased rectal temperature, respiration rate, water intake and decreased feed intake, lowers the level of rumen VFA content. Present evidence also indicates a good relation between the ability to re-adjust to VFA levels under hot conditions and general tolerance. (AH g4-1)

6. Evaporative Losses of Holstein Cows at 70 and 90° F.

Six mature, nonlactating Holstein cows were kept in a psychrometric chamber for 12 weeks of alternate 2-week periods of 70 and 90° F. At weekly intervals the total evaporative loss was determined from the difference between the weight of the animal at 0800 and 1100 hours, less the weight of urine, saliva and feces collected during the three hours. Respiratory evaporative loss was estimated from the

volume and moisture content of the expired air. The difference between total and respiratory losses was used as an estimate of surface evaporation. Body surface area was determined with a surface integrator. The average total evaporation increased from 118.2 gm/m²/hr at 70° F. to 221.0 after one week at 90° F. and 243.2 gm/m²/hr after two weeks at 90°F. Respiratory evaporation accounted for 49.3, 65.7, and 69.5 gm/m²/hr during the same intervals. Surface evaporation increased from 69.0 gm/m²/hr at 70° F. to 155.2 and 173.8 gm/m²/hr after one and two weeks at 90° F. Both surface and respiratory evaporation increased at 90° F., but surface evaporation did so to a much greater extent. Surface evaporation accounted for 58.3% of the estimated total evaporative losses at 70° F. and 70.3% and 71.4% after one and two weeks at 90° F. From this study it is evident that Holstein cows can effectively use surface and respiratory cooling under hot conditions (20.0 therms of energy per day). The present study also lends support to mounting evidence that between cow variation in the ability to utilize surface evaporation is large in the Holstein breed. (AH g4-1)

7. Heat Tolerance Studies in Brazil.

Studies on European breeds (Brown Swiss, Holstein, Jersey); Zebu breeds (Nellore and Kankrej) and crosses of European and Zebu in a psychrometric chamber at the Instituto de Zootecnia, Brazil, under 105° F. temperature showed that cholinesterase activity of the blood declines quite rapidly upon exposure to heat stress. The decline is most marked in pure European breeds and the recovery period is also longer in the pure European breeds. The change of cholinesterase in the Zebu-European crosses seems to be more like that of the Zebu than the European breeds. (S3-AH-7)

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AREA NO. 7 - DAIRY CATTLE - NUTRITION AND MANAGEMENT

Problem. Information on the nutritional processes and requirements of dairy cattle are needed to obtain a more precise evaluation of feeds and rations as a basis for improving feeding practices on farms. Shifts in sources of nutrients fed to dairy cattle require studies on the optimum combination and specific supplements needed in order to provide for the most profitable production. Also, dairymen need to reduce costs including man-hours of labor and develop better management in the use of improved types of dairy equipment and feeding, bedding, and milk handling systems.

USDA PROGRAM

The current program is conducted by biochemists, nutritionists, and dairy husbandmen. At Beltsville, studies are in progress on the factors which contribute to the heat production and maintenance requirements of grazing animals; the relationship between net energy, metabolizable energy, and total digestible nutrient values in dry roughages, silages, green roughages and concentrates; and the relationship between digestibility and the chemical composition and solubility of various feed constituents. Calorimetric techniques are being applied to studies on the effects of dietary and physiological factors on energy metabolism and requirements of cattle. A cooperative project at Tifton, Georgia, has been recently initiated on the residues in milk resulting from the ingestion of pesticides and herbicides associated with the treatment of animals and crops. At Cornell University a Nutritionist is being trained in radioisotope methodology and technical problems associated with exposure to Strontium 90 and similar radiation products.

At Beltsville, Maryland, research is being conducted on the effects of crop maturity, moisture content, preservatives, including methods of handling and conditions of storage, on the chemical quality, palatability and feeding value of silages. In conjunction with this effort, biochemical studies are being made to determine the effect of the composition of forage at the time of ensiling and of varying imposed conditions on the composition of the resulting silage. Microbiological studies are being carried out to obtain information on the microorganisms responsible for the fermentation process of ensiled forages and on the relationships of these processes to the biochemical and nutritive changes that occur in ensiled forage. Related to the Beltsville studies is cooperative work at Lewisburg, Tennessee; Willard, North Carolina; and Puyallup, Washington. The objective of the work at the former station is to determine the effectiveness of various practical ensiling procedures by varying such factors as moisture, preservatives, type of silo, etc. At North Carolina, comparisons are

being made of upright and bunker type silos. At Washington, the scientists are studying comparisons of bunker and tower silos. Pasture studies at Beltsville, Maryland, involve the effect of varying stocking rates on nutrient yields per acre and on production per animal. In cooperation with the Washington State Experiment Station at Puyallup, Washington, work is being carried out to determine dry matter consumption and digestibility of nutrients from pasture species.

A cooperative project at Logan, Utah, has been undertaken to measure the variations in efficiency of forage utilization by dairy heifers and to determine the factors which account for these variations.

At Beltsville, Maryland, a continuing study is underway to obtain information on the extent of the variation in amount of dry matter and total digestible nutrients the dry, nonpregnant, mature cow requires to maintain body weight under practical conditions and to study and evaluate various factors that may influence the maintenance requirements.

The work at Beltsville, Maryland, also consists of studies on wilted silage as a forage for growing dairy heifers, the vitamin and mineral requirements of calves and deficiency symptoms using a synthetic type of diet with particular emphasis on vitamin A and magnesium deficiency. At Willard, North Carolina, the research involves pasture utilization by young, growing cattle.

Scientists at Beltsville are engaged in studies on the environmental conditions and the mechanisms of infection involved in bovine mastitis. They are also making a comparison of hand vs. machine milking of dairy cattle. In cooperation with Agricultural Engineering, Entomology, and Eastern Utilization, research is in progress on electrically-controlled and operated equipment for reduction of labor in dairy cattle management; on the evaluation and development of physical methods for control of flies and other dairy cattle pests; and on the relationship between management practices and milk quality including flavors.

Cooperative work with Agricultural Engineering and with the Georgia Coastal Plain Experiment Station is being conducted on the influence of management practices and other environmental factors on the adaptability of cattle to the Southeastern United States.

The Federal scientific effort devoted to research in this area totals 26.4 professional man-years. Of these 6.0 are in digestion and metabolism, 11.1 in forages, 2.6 in nutritional requirements, 3.1 in calf feeding, 2.7 in management practices, and 0.9 in program leadership.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State experiment stations reported a total of 87.6 professional man-years of which 22.0 are on digestion and metabolism, 7.5 on concentrates; 30.0, forages; 7.9, nutrients; 8.7, calf feeding; and 11.5, management practices, equipment, and facilities.

Research in digestion and metabolism seeks to develop basic information about the role and action of rumen microorganisms in the nutrition of the dairy cow, characterization of the most desirable types of organisms and determinations of the ideal media and conditions for maximum rumen fermentation. Other studies are concerned with the development of rapid chemical and/or bacteriological tests for predicting digestibility and the reasons for differences in net energy values between roughages and concentrates. Ketosis and milk fever is under investigation to learn why some cows are affected and some are not. Intermediary metabolism, the process of converting the products of digestion into milk and butterfat, is another basic problem under intensive study.

Current problems under investigation on concentrates include the evaluation of innumerable nonprotein nitrogenous products, the pelleting of the ration including grain, and the effects of feeding on udder edema. Other studies seek to determine the effects of heating on the availability of certain nutrients in the ration, the value and use of sorghum grains, and the losses incurred through fermentation of grain in silage.

Research on forages deals with the losses incurred in the digestion of forages, especially rumen fermentation; ways in which high quality (principally low fiber, high protein content) can be maintained or improved, and palatability and its effect on consumption. Several stations are evaluating different methods of feeding forage, i.e., grazing, as a soiling crop, and rotation vs. strip grazing. Other stations are studying forage preservation, comparing the feeding value of field cured forage vs. artificial drying, vs. silage. Still other stations are investigating the effect of the physical character of the forages when fed, such as long hay, chopped, ground, pelleted, or cubed. Virtually every State is involved in one or more phases of forage research, including the value of locally adapted crops and the investigation of new problems such as the cause of profuse salivation while grazing, nitrate poisoning, etc.

Included in research on nutrients are basic studies on carotene and its conversion to vitamin A, the various levels and kinds of protein that result in maximum milk secretion, and the factors affecting the absorption and utilization of minerals including the role of less well understood minerals such as selenium, molybdenum and zinc. Other

studies seek to determine the kinds and quantity of fat a cow can tolerate, and the feasibility of giving cows tranquilizers, antibiotics or hormones.

Basic problems on calf feeding concern the nutrient value of filled milks, the minimum milk and fat requirements of calves, and the necessity of providing the young calf with liquid food which solidifies as soon as it reaches the true stomach. Dairy scientists are studying the prenatal as well as the postnatal nutrient requirements of calves. The value of pathogen-free calves on purified diets is being tested. Medicated feeds as well as antibiotics are added to the diets of very young calves, especially those receiving no colostrum. Nonpathogenic types of diarrhea are also being investigated. One station is studying the importance of the fat-splitting enzymes secreted in the oral cavity and their significance in fat digestion. Another station is determining the importance of vitamin A to the calf's growth, sight, manner and places of storage in the body. Still other stations are concerned with carbohydrate utilization and the synthesis of B-complex vitamins in the rumen. Blood values are also being studied more intensively and including determination of feeds likely to alter normal blood levels.

Most of the research on management practices, equipment and facilities is limited to information which can be gathered from herd records, such as the effect of length of dry period on the succeeding lactation, or the effect of early breeding on the health and lifetime production of high producing cattle. Probably the most elaborate current trial dealing with herd management is at the Pennsylvania station where three systems of handling cattle are under study, using separate barns and herds but as nearly as possible the same managerial ability. Effects of automation, machine milking, sanitizing, etc., will be reviewed in other sections.

The research in industry on dairy cattle nutrition is conducted primarily by the feed manufacturing companies. The largest portion of the work is involved with vitamin requirements and ration comparisons for calves with particular emphasis on milk replacers. Ration comparison as well as supplementation and feed additives trials are conducted with lactating cattle. The estimated activity in this field by industry amounts to approximately 60 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Digestion and Metabolism

There is considerable question concerning the most accurate method of evaluating and expressing the energy values of feeds, whether by means of total digestible nutrients, digestible energy, metabolizable

energy or net energy. An energy laboratory was established to study these methods as well as to inquire into the various fundamental metabolic factors which might affect the efficiency of feed utilization.

1. Effect of Stage of Maturity and Plane of Nutrition on Energy Values of Forage.

Early-cut alfalfa, late-cut alfalfa and late-cut orchard grass were harvested, pelleted and fed to nonlactating dairy cows at three planes of nutrition: 50% maintenance, 100% maintenance and ad libitum. A total of 104 digestibility trials, 108, 24-hour respiration and 84, 24-hour fasting respiration trials have been completed. While all the data have not been calculated, animal variation in ad libitum consumption of pellets was noted, but the plane of nutrition effects on apparent digestibility were small. The apparent digestibility of dry matter, organic matter, gross energy, nitrogen and carbon decreased with increased stage of maturity and the digestibility of all these constituents was less for orchard grass than for alfalfa cut on the same day. The average for all determinations in terms of digestible energy per lb. were for early-cut alfalfa 1217, late-cut alfalfa 1021, late-cut orchard grass 991. Ad libitum consumption as percent of maintenance was 144, 151, and 121, respectively. (AH h2-8)

2. Carbon Analysis.

Using the conventional wet combustion carbon train, 892 samples analyzed in the above experiment required the time of one person for 112 days. A Leco induction furnace and carbon determinator were obtained by which the same data could be obtained in 18 days. It was found necessary to alter the catalyst for the combustion of the samples of biological material. These investigations have resulted in the development of an accurate method for rapid carbon analysis with a considerable saving of time, since carbon analyses are so important in energy balance trials. (AH h2-8)

3. Preservation of Excreta.

Adequate methods for the preservation of excreta without losses of volatile materials for analysis at a later date are important in energy balance trials.

The results of studies on freezing, canning and drying as methods of preserving bovine feces for chemical analysis have been summarized. Analytical results indicated that there were no detectable differences in the gross energy of feces which could be attributed to method of preservation. However, highly significant ($p < 0.01$) losses of nitrogen occurred when feces were dried, regardless of the temperature (61-80° C.)

or length of time (6-48 hr.) used to dry the samples. Canning and freezing were equally effective as a means of storing the samples without nitrogen loss. Canning was found to be a convenient means of storing samples at room temperature for extended periods. In general, it may be concluded that samples of feces may be stored for nitrogen, carbon and gross energy analyses by freezing or canning, and that gross energy determinations may be made on dried, pulverized samples. Freezing would be the method of choice for urine. (AH h2-8)

4. Absorption of Methane and Carbon Dioxide from the Rumen.

When feeds in the rumen undergo bacterial fermentation, methane and carbon dioxide gases are produced. In the metabolism of nutrients within the body tissues carbon dioxide is also produced. In making certain calculations in energy balance trials, it is necessary to know the proportion of carbon dioxide which is produced in the body proper and the portion produced by the fermentation of feed in the intestinal tract.

In order to study this problem, tracheostomized Jersey cows were used, in which the eructed gas and respired gas from the lungs could be separately collected. The cows were fed two different rations, a ration of forage and a feed lot bloat-producing ration (61% barley, 22% alfalfa, 16% soya oil meal and 1% salt). Carbon dioxide absorption from the rumen was calculated from the radioactivity in the expired and eructed gas during the continuous infusion of C^{14} -labelled carbonate into the rumen. When hay was the ration, 0.93 liters of methane per hour were produced before feeding with 73% being absorbed. In the same order, when grain was fed, the figures before feeding were 2.19 l./hr. and 51%, and after feeding 6.25 l./hr. and 20%. When hay was fed, 5.5 l./hr. of carbon dioxide were produced before feeding with 89% being absorbed. After feeding, 17.4 l./hr. were produced with 67% being absorbed. When grain was the ration, the figures were 5.4 l./hr. and 69% absorption before feeding, and 24.9 l./hr. and 45% absorption after feeding. Not only does the proportion of gas absorbed through the rumen depend upon the time of feeding, but it is also noteworthy that less carbon dioxide was absorbed through the rumen wall when the cows were fed the grain ration than when fed the hay ration. The data raise several questions which need further clarification and point out that the amount or proportion of CO_2 absorbed is dependent upon the type of ration fed. (AH h2-8)

5. Chemical Methods for Determining the Nutritive Value of Feeds and Forages.

These studies during the past year include the investigation, choice and development of suitable chemical methods to be applied in the analysis of forages for the comparison of chemical composition with digestibility.

Continued progress has been made in applying the use of detergents in the formulation of suitable procedures for fiber and lignin. Early in the year it was determined that a quaternary detergent, hexadecyltrimethylammonium bromide (CTAB), was superior to other detergents in the solution of proteins from the dry matter residue of forages. Utilizing this principle, a simplified and rapid procedure for fiber (termed acid detergent fiber which includes the lignin) was developed. A simplified lignin method was also developed. Detailed studies have been made in regard to the effect of concentrations of the CTAB detergent, acid concentration and time of boiling upon the yield of acid detergent fiber and its composition in respect to protein and lignin. The adopted procedure consists of refluxing with normal sulfuric acid containing two percent CTAB for one hour. Preliminary solvent extraction has been eliminated by the addition of two ml. of decahydronaphthalene to the reflux mixture. The lignin analysis is made upon the acid fiber residue with 72% sulfuric acid.

Results obtained with various forages show that acid detergent fiber residue consists chiefly of lignocellulose with a small amount of protein which seems to be firmly bound to the fiber. A correlation of -0.75 was obtained for the acid detergent fiber with digestibility of the dry matter. For lignin separately, the correlation with digestibility was -0.92. The corresponding correlation for crude fiber was -0.71. Sixteen comparisons were available for the lignin correlation, and 18 for those of the acid detergent fiber and crude fiber, including both grass and legumes species. The lignin obtained appears indigestible on four feed-feces comparisons. Further studies on the composition of lignin will have to be made before final conclusions can be made on the relationship between different lignin methods. With such a high negative correlation between lignin and digestibility (-0.92) for both grasses and legumes, it appears that the proposed procedure is quite promising.

Studies on the composition of the acid detergent fiber residue reveal that it contains on the average about 10% of the total feed nitrogen. This nitrogen appears to have a low digestibility and the amount remaining in the residue is associated negatively with digestible crude protein and positively with the amount of nitrogen undissolved by pepsin. The detergent is considerably more efficient in the removal of nitrogen from plant tissue than commonly used pepsin. Acid detergent removed in one hour a greater proportion of the nitrogen than pepsin digestion removed in 40 hours. Studies on the effects of heating and drying show that heating above 80° C. renders the protein less soluble in either detergent or pepsin. This observation is also associated with low in vivo protein utilization. This procedure may prove useful for determining the effect of heat application on the digestibility of feeds. (AH h2-6)

6. Agricultural Chemicals in Milk.

a. Effect of Oral Administration of Diazinon to Cows and Its Excretion into Milk.

At Beltsville a 25% diazinon wettable powder in capsules was fed to lactating dairy cows at rates of 0, 10, 50, 100, 250, and 500 p.p.m. of the dry matter intake per day. The milk fat separated from the milk was analyzed by a method published by the Geigy Chemical Co. No diazinon per se was detected in the milk fat. While some breakdown products of diazinon might be secreted into milk, it must be concluded that no diazinon as such is secreted into milk. (AH h2-9)

b. Stability of Diazinon in Silage.

At Tifton, Georgia, immature chopped rye grass was sprayed with emulsifiable diazinon in water at the rate of 10 and 100 p.p.m. of fresh forage. The silage was then packed and sealed into quart glass jars. The jars were opened at 5, 12, and 22 days. The results showed that there was a gradual destruction of the diazinon in the silage. After 22 days only about 3% of the diazinon remained in the silage. It can be concluded that after a reasonable period of storage, diazinon as such would not be present in silage and the silage could be fed to animals. (AH h2-9)

c. Dimethoate Secretion into Milk.

At Tifton, Georgia, a field of corn was sprayed with 0, 4, 8, and 16 ounces of dimethoate (in 100 gallons of water) per acre at 100 psi's pressure. After allowing the spray material to dry on the plant, the corn was harvested as silage and stored in ground stack silos covered with 4 mil polyethylene plastic weighted down with sawdust. There were three replications for each insecticide level. After nine weeks storage, 50% of the dimethoate was still present in the four-ounce treatment, the lowest level of treatment. During the 28-day feeding test the dimethoate averaged 1.2, 2.6, and 5.3 p.p.m. in the silage. The silage had a somewhat pungent and disagreeable odor related to the levels of dimethoate used. The odor affected the intake of silage and the cows were erratic in acceptance of the silage. A detectable amount of dimethoate appeared in the milk (0.01 p.p.m.) 14 days after feeding began. None was detectable 14 days after feeding was terminated. One animal fed the 16-ounce treated silage developed toxic symptoms and had to be slaughtered. It appears that dimethoate can remain in corn silage and be excreted into milk. However, from data collected with other plant material, it is probable that if dimethoate were applied to plants in the field two weeks before harvest, most of it will have disappeared. (AH h2-9)

B. Forage Evaluation and Utilization

1. Silages.

a. Nitrate Relationships in Silage.

- (1) Effect of nitrogen fertilization on quality and feeding value of silage.

The use of nitrogen fertilizer has become a widely accepted method of increasing both yield and protein content of grass forages. An increase has been observed in digestible energy as well as digestible protein of grass hays with nitrogen fertilization. Information on the ensiling of nitrogen fertilized grass crops is not available. A direct comparison was made of storage losses, chemical quality and feeding value of first-cutting orchard grass direct cut harvested as unfertilized and fertilized forage (400 lbs/acre ammonium nitrate) stored in two upright silos. Under the conditions of this experiment the application of nitrogen 15 days prior to harvest resulted in greater loss of stored dry matter (15.1% vs. 21.5%), higher protein content (14.1% vs. 25.2%) and a decidedly inferior quality of silage (pH 4.0 vs. 5.0) ammoniacal nitrogen as protein (7.7% vs. 21.7%) and a higher butyric acid content (0.2% vs. 2.2%). Despite the quality differences in the silage, they were about equal in feeding value.

- (2) Effect of nitrogen and molybdenum fertilizer on silage.

The importance of molybdenum in coenzyme systems for reduction of nitrate to ammonia in plants suggested that a deficiency of this element might limit the reduction process in highly fertilized orchard grass and result in nitrate accumulation in the plant. Four treatments consisting of all combinations of 0 or 800 pounds of ammonium nitrate per acre and 0 or 1.0 pounds of sodium molybdate per acre were applied July 14 in three replications to a third cutting orchard grass field making a total of 12 plots. Neither accumulation of nitrate, crude protein nor reducing sugar content of the orchard grass was affected by molybdenum fertilizer with or without nitrate fertilization. Some of the forages which were ensiled in quart jars showed quality characteristics which were contrary to previous findings. For instance, low protein forage produced silage of higher butyric and lower lactic acid content than did high protein forage. Grinding adversely affected chemical quality in low protein forage but had the opposite effect on high protein forage. Further fundamental observations on these effects are required to explain them.
(AH h3-3)

Other work with ensiling high nitrate orchard grass forage showed a considerable reduction in nitrate content during the first three days after ensiling. It was also noted that if there was an increase in pH of the silage a further decrease in nitrate was noted. Such would be inimical to the preservation of high quality forage. Addition of sugar with a rapid reduction in pH permitted more nitrate to remain in the silage. (AH h3-1)

(3) Nitrate reducing organisms in silage.

A study was made on the nitrate reducing enterococci isolated from silage. This particular group was of interest because they have previously been classified on the basis of being unable to reduce nitrate. The results showed that media composition (nutrition), temperature, pH and oxygen had considerable influence on growth and reduction of nitrate by this group of organisms. Steps of reduction were examined and it was shown that the strains were capable of reducing nitrate to ammonia. Organisms of this type may be important in reducing high levels of nitrates in forages which have been shown to be toxic to animals. (AH h3-2)

(4) Nitrogen fertilization and silage bacteria.

In data collected elsewhere in this work project, it is pointed out that nitrogen fertilized forages are more difficult to ensile than nonfertilized forage. Studies were also conducted on the numbers and types of bacteria present in the two types of silage as well as to investigate the bacteria which will reduce nitrate. The results showed that while nitrogen fertilization caused considerable change in the chemical composition of the harvested forage, the numbers and types of bacteria present in the silage were not greatly changed. These observations confirm previous data that except for the anaerobic sporeformers the bacterial population in silage is not greatly altered in numbers and species indicating a rather stable situation. Bacteria were present in the silage population which could reduce nitrate suggesting that this is one pathway by which the nitrate reduction takes place. (AH h3-2)

b. Harvesting Methods & Storage Structures.

(1) Measurement of degree of laceration of forage

It has been demonstrated that laceration or bruising of plant tissue prior to ensiling aids in the preservation of silage in small laboratory silos. However, in experimental work there has been no objective method of measuring the degree of laceration. From a suggestion published from England that specific gravity of the forage before and after laceration would be a good index, an apparatus was

constructed for this purpose. For instance, the specific gravity of the forage cut by a field chopper was 0.79, for a Letz chopper 0.8, for a Silorator 0.84, and for a food grinder 1.05 (AH h3-1)

(2) Effect of laceration on silage quality.

Some data collected several years ago at Beltsville on a small-scale basis with quart jars and 4' x 8' silos indicated that bruising or laceration of forage at the time of ensiling improved the quality characteristics of the resulting silage through more favorable fermentation conditions. A large-scale trial was conducted at Lewisburg, Tennessee, in cooperation with the University of Tennessee on the effect of bruising of grass legume silage as against chopping and storing in large silos. Comparisons were made on dry matter consumed, chemical composition and feeding value in terms of consumption of dry matter and milk production of the two silages. No significant differences were noted between any of the factors measured except for ammoniacal nitrogen expressed as crude protein. The values were 3.2% for control silage and 2.5% for the bruised silage. Under the experimental conditions at Tennessee, bruising in a practical large-scale operation caused little improvement in the quality or feeding value of the silage. The experiment is being conducted a second year. (AH h3-9)

(3) Chopped and ground forage.

Exposure of orchard grass forage to air for 8 hours after chopping or grinding but before ensiling in quart jars produced increased counts of anaerobic sporeformers at 60 days after ensiling as compared to forage ensiled with a minimum (0 hours) of exposure. This increased count, which has been associated with decreased chemical quality, developed during the period following ensiling. (AH h3-2)

(4) Use of tower and bunker silos.

At Willard, North Carolina, corn and Sart Sorghum crops were harvested and stored in two bunker and two tower silos. More corn silage dry matter was preserved in tower than the bunker silo (87.9% vs. 74.3%). Likewise, more Sart dry matter was preserved in the tower silos than in the bunker silo (69.5% vs. 65.9%). Under the conditions used at Willard, the tower silos were more efficient in the preservation of dry matter than the bunker silos.

At Beltsville, Maryland, corn silage stored in a bunker silo showed a dry matter loss of 12% which is as good as would be expected in a tower silo. The silage was packed with a bulldozer, sealed and weighted with plastic and sawdust. Silo capacity was less than previously observed when packing was done with a wheel type tractor. (AH h3-3)
(In cooperation with the Agricultural Engineering Research Division).

(5) Production of low-moisture silage in tower silos.

Because high dry matter silage is consumed in greater amounts than silage with a low dry matter content, an experiment was run to determine whether high dry matter silage could be stored in tower silos. High dry matter silage from first-cutting alfalfa was successfully stored in two conventional tower silos. Some forage contained 65% dry matter when stored but the average for the silos was about 42%. A dry matter recovery of 95% was obtained as silage and no excessive heating or spoilage was observed as a result of fine chopping, careful distribution, tramping and top sealing. The resulting silage was equal in feeding value to barn-dried hay made at the same time from the same crop when fed to milking cows and dairy heifers. The results indicate that a satisfactory harvesting and feeding program can be developed with high dry matter silage as the only forage.

(6) Preservation of wilted alfalfa silage in bunker silos.

In previous work at Beltsville, crops stored in bunker silos have been direct cut so that the full initial moisture content could be utilized as an aid to consolidation and air exclusion. Silage containing up to 40% dry matter was successfully stored in a bunker silo and 87% of the dry matter was recovered for feeding. Although spoilage was well controlled by sealing with plastic sheeting, each successive layer from the top in the silo was more efficiently preserved. The exposure of forage which occurred when filling was stopped during the night and during one day of bad weather resulted in distinctly lower chemical quality compared to portions which were promptly protected from the air. These observations support the idea that rapid filling and sealing is a good practice to follow. The results also demonstrate that wilted silage can be stored in a bunker silo when proper packing and sealing the silo is accomplished. (AH h3-3)

(7) Effects of water added after wilting on silage quality.

This work was undertaken to estimate whether water added to wilted forage at the time of ensiling would have any effect on quality of the resulting silage. This would also simulate a field situation where wilted forage was rained on in the field and provide information as to the necessity of removing the added water (rain) before ensiling. The possibility also existed that the quality of silage could be improved if better packing and consolidation could be achieved by adding water without adversely affecting silage fermentation. Results indicated that the improvement of silage fermentation by wilting is related to the lower moisture level per se and that the addition of water at the time of ensiling tends to negate these improvements.

Limited acceptability trials showed that wilting up to 65% dry matter resulted in increased consumption rates compared to wilting to 48%.

(8) Silages in the Puget Sound area.

This project is conducted in cooperation with the Washington Agricultural Experiment Station at Pullman, Washington. Because of climatic conditions and the difficulty of producing wilted silage in the Puget Sound area, methods of utilizing direct-cut high moisture silage were investigated. Four groups of cows were fed two levels of grain and two levels of hay with the high moisture silage. There were no differences in milk production for the levels of hay feeding (13.3 lbs. per day vs. 6.9 lbs. per day). There were differences in milk production for high and low level of grain feeding (20 lbs./day vs. 9.5 lbs./day). The difference in milk production was 3.8 pounds milk per day. There was a higher concentration of protein and solids-not-fat in the milk produced on the higher levels of grain feeding. Under the conditions of the Puget Sound area where direct-cut silage is made, it may be necessary to feed more heavily on concentrates to obtain an optimal level of milk production. (AH h3-7)

c. Preservatives.

(1) Tylosin (an antibiotic).

Tylosin is an inhibitory substance obtained from Streptomycin. It is especially active against sporeforming anaerobes. The sporeforming anaerobes are largely responsible for the production of poor quality silage. To be effective in silage the antibiotic must inhibit the growth of sporeformers but permit the growth of lactic acid bacteria which produce the acid necessary to preserve the silage.

In experiments with pure media, it was demonstrated that the lactic acid producing bacteria were able to grow in all concentrations of tylosin (0.5 to 2 p.p.m.) but the sporeforming clostridia were unable to tolerate the lowest level used (0.5 p.p.m.). This suggested that the antibiotic showed differentiation between the two species of bacteria and that its application to silage making might be useful.

The next step was to study the effect of the antibiotic when introduced into silage slurries under various conditions. Sluf slurries under oxygen, nitrogen, with and without added inoculum of sporeformers and different levels of antibiotic were studied. The results showed that under a nitrogen atmosphere, a condition comparable to actual silo conditions, tylosin was effective in permitting a reduction of the pH of the slurry (control pH 5.07, 1 p.p.m. tylosin pH 4.32, 5.0 p.p.m. tylosin pH 4.20). Under oxygen there was evidence of destruction of tylosin. These results gave encouragement to proceed one step further by use of quart jars and 4' x 8' silos.

Forage ensiled in quart jars and 4' x 8' silos showed that the tylosin permitted a decrease in pH which resulted in the production of good quality silage.

The results to date are quite encouraging on the use of tylosin as a silage antibiotic and should be pursued further under more acute stress situations. (AH h3-2)

(2) Silotracin.

From time to time antibiotics have been proposed as a silage preservative. Direct-cut third cutting alfalfa was ensiled in 4' x 8' silos. Silotracin was added to one silo at the rate of 5 pounds per ton of forage. The fresh cut forage contained 20% dry matter and 19% protein on a dry basis. Both silages were of good quality. Silotracin showed no positive effect but had no deleterious effect. (AH h3-3)

d. Feeding Value of Corn and Sorghum Silages.

At Willard, North Carolina, one comparison of corn and Sart Sorghum silages using two levels of protein in the concentrate ration showed that there was greater consumption of corn silage and more milk was produced (24.4 lbs. vs. 21.5 lbs. FCM). The cows fed the 22% protein concentrate ration produced more milk than those fed 18% protein (25.3 lbs. vs. 23.5 lbs. FCM). There was no difference between the Sart Sorghum silage groups in this respect. Heifers fed the corn silage with 3.0 pounds of grain out gained those fed the Sart Sorghum silage. In digestibility trials with steers there was no difference in digestibility of dry matter between the two silages. In a further experiment comparing corn, Sart and Hegari silage, corn and Hegari were about equal in feeding value with Sart less valuable. The results show that corn silage and Hegari are more acceptable than Sart silage to dairy cattle and they produced more milk and more gain. (AH h3-8)

e. Biochemical Studies.

(1) Sugar-protein ratio in silage.

In the fermentation process in the silo, certain bacteria convert the readily available sugars and carbohydrates to organic acids such as lactic, acetic, formic and propionic which increases the acidity of the silage to a low pH so that the forage will be preserved. On the other hand, some bacteria break down the protein and nonprotein fractions in the silage to ammonia and other nitrogenous products. The ammonia produced tends to neutralize the organic acids and increase the pH which is detrimental. Also, some of the bacteria

change the lactic acid to butyric acid which also permits an increase in pH and results in poor quality silage. It would appear that some balance of sugar and protein is required in the fermentation process and that high protein forage is more difficult to ensile because it requires more readily available sugar for the formation of acids. Using quart jar silos with 46 orchard grass silages, a good correlation was observed between sugar and protein content of the forage and the resulting pH of the silage.

When the sugar content of the forage ensiled was 13.5% of the protein content (4.28% sugar and 31.5% crude protein), the resulting silage had a pH of 7.05 with 16.5% ammonia N expressed as protein. When the sugar to protein ratio was increased to 37.5% by the addition of sugar, the pH of the silage was 4.1 with only 2.0% ammonia N expressed as protein.

These fundamental relationships require further study and do offer some promise of being useful in the ensiling of high protein crops. (AH h3-1)

(2) Mineral relationships in silage.

It has been suggested that the minerals present in the forage at the time of ensiling might have some affect on the fermentation process. Salts of potassium, magnesium, manganese, copper, zinc, and cobalt were dissolved in water and applied to forage at the time of ensiling. Preliminary data in small silos indicate that the minerals produced a silage with a lower pH and a higher lactic acid content than the untreated forage. (AH h3-1)

(3) Protein determination in the presence of nitrate.

In the determination of the protein content of forage by the Kjeldahl procedure the nitrogen in the nitrate would be determined as protein resulting in considerable error. It was found that by the addition of 70 ml of water and 6 grams of sodium chloride the nitrates would be removed from the digestion mixture, before the addition of concentrated sulfuric acid and mercuric oxide. The effect of the presence of other constituents is being studied before the procedure will be recommended. (AH h3-1)

(4) Separation of amines.

In connection with the problem of acceptability of silage by cattle, it has been suggested that the amine concentration in the silage might be a factor to be considered. However, no very simple method of analysis of amines is available. A method was

developed using partition chromatography with celite columns. The columns are eluted with varying proportions of acetone and hexane. Ammonia and trimethyl amine were easily separated by the use of the column. One sample of silage was found to contain 0.63% trimethyl amine. The new method will materially aid further studies on elucidation of factors concerned with silage acceptability. (AH h3-1)

2. Pastures.

a. Coastal Bermuda Grass for Dairy Cows.

In the coastal area where Willard, North Carolina, is located, the usual pasture grasses do not produce well. The answer to this problem has centered around the development and use of annual crops for this purpose. With the advent of Coastal Bermuda Grass as a perennial grass for pasture use with beef cattle, it was felt that the grass should be studied for its use with dairy cattle. A comparison was made between rotationally grazed Coastal Bermuda Grass, rotationally grazed Starr Millet and ad libitum feeding of small grain-crimson clover silage. Jersey cows producing about 40 pounds of milk per day declined at the rate of 12.9% per month on the Bermuda Grass, 10.9% on Starr Millet and 20.5% on the small grain-crimson clover silage. Thus, the Coastal Bermuda Grass compared favorably with the Starr Millet and warrants further investigation. (AH h3-10)

b. Stocking Rate of Dairy Cows on Orchard Grass Ladino Pasture.

The effects of intensive, moderate and liberal utilization of rotational pastures on the productivity of pastures and animals was continued at Beltsville in 1961 for the second consecutive season.

In a statistically designed experiment, the different degrees of intensity of grazing were obtained by keeping an equal number of cows on plots of different size ($1/2$, $3/4$ and 1 acre) for the same number of days. This resulted in very intense nearly complete utilization of the $1/2$ acre plots, moderate utilization of the $3/4$ acre plots and a low or liberal level of utilization of the 1 acre plots.

Analysis of the 1960 data showed that per acre animal production under moderate and liberal utilization was about 80 and 70%, respectively, of that obtained under intensive utilization. The animals on intensive, moderate and liberal regimes obtained .70, .47 and .37 pounds of TDN, respectively, from each pound of dry matter available to them based on field samples. Thus, it was shown that utilization management has a powerful influence on the productivity of pastures.

The effects of these regimes on daily production of tester cows were in the expected direction with more intensive utilization being

associated with lower production per cow per day. However, because of the large differences in individual cow response to the same treatments, average treatment differences for the season were not statistically significant. These data indicate that a much larger or more homogeneous cow population is required to demonstrate significantly different effects on per animal production at these levels of utilization stress.

Intensive utilization resulted in a small reduction of the digestibility of the organic matter consumed and a one-third reduction in the daily intake of digestible organic matter as compared to liberal management. Moderate utilization produced an intermediate change in both of these values. When it was assumed that animal determined values for seasonal dry matter consumption per acre were correct, the values estimated from field samples yielded an under estimate of 5% and over estimates of 12 and 30% for the intense, moderate and liberal systems, respectively. This indicates a serious interaction of methods of estimating dry matter consumed and intensity of utilization.

The detrimental effects of intensive utilization on regrowth vigor of the pasture plants were increasingly apparent as the 1961 season progressed. This resulted in a lower production of available forage per acre under this regime. It appears at present that milking cows may be more adaptable to nearly complete pasture utilization than are the pasture plants.

Data obtained so far indicate that improved pasture can be more thoroughly utilized than is generally thought to be the case without a prohibitive reduction in per animal production and with a marked increase in per acre production. However, this intense utilization may have to be coupled with very short grazing periods to accommodate for the strength and recovery of the pasture plants. (AH h3-18)

C. Nutritional Requirements

1. Maintenance Requirement for Stanchioned Nonlactating Cows.

The maintenance requirement found for stanchioned nonlactating dairy cows in this investigation was approximately 13.00 pounds alfalfa dry matter per 1,000 pounds liveweight. The TDN value of the pre-dominant hay used in this trial was found to be 56.5% and the digestible energy content was 57.5%. Thus the maintenance requirement was 7.35 pounds TDN/1000 pounds. This is within the ranges of other data reported which indicates that one pound TDN for maintenance was equal to 58% and 103% of the therms of metabolizable and net energy, respectively.

The values calculated by Brody and Gaines were obtained from production record data by mathematically partitioning intake into that used for

milk production, maintenance and gain. The values so obtained of 8.2 and 9.9 pounds TDN per 1,000 pounds liveweight are higher than other values obtained by direct observations. Reasons for this are not apparent but may be due to methods of calculation or to a difference between "working" and "idle" maintenance requirements. The values reported in the literature for bulls were approximately 8.1 to 8.5 pounds TDN per 1,000 pounds liveweight which is somewhat above the values found for cows. (AH h2-4)

2. Maintenance Requirement During Winter and Summer Seasons.

The amount of alfalfa dry matter consumed from the last week in May to the first week in September was compared to that consumed from the last week in November to the first week in March for 15 cows with 21 observations during each season. Similar information on 3 cows fed 30.5% grain and 69.5% alfalfa was also obtained. The average weights during summer and winter seasons were practically identical. The net amount of feed consumed with no body weight change was practically the same in summer months as during the winter months when either of two weight change correction factors was used. The relationship between body weight and adjusted intake was calculated for both the summer and winter seasons and found to be practically identical using the 21 observations when cows were fed only alfalfa hay. The relationship found from data in summer was alfalfa D.M. for maintenance = $0.3958W^{.507}$ and for winter = $0.3966W^{.51}$. The calculated requirement for a 1,000 pound cow was 13.13 and 13.25 pounds alfalfa D.M. for summer and winter, respectively. These data indicate that the amount of feed required to maintain constant body weight was the same for summer as for winter seasons under the conditions of these trials. (AH h2-4)

3. Maintenance Requirement Before and After Ovariectomy.

The intake, body weight, and its changes for 3 cows fed alfalfa hay before and after removal of the ovaries were measured. Calculations showed that each cow required less feed to maintain the same body weight with no weight change after removal of the ovaries. (AH h2-4)

4. Maintenance Requirements of the Grazing Cow.

In order to gain further information on the maintenance requirements of grazing cattle, three cows were subjected to three treatments. In one treatment a cow was strip grazed. In a second treatment another cow was fed forage clipped from a similar adjacent area while tied to a feed manger in the pasture field, while in the third treatment a cow was fed the same clipped forage while being housed in a respiration chamber in an air-conditioned laboratory.

Each cow was rotated through all three treatments. The maintenance requirements by regressing heat production values to zero feed intake for a 1,000 pounds animal were 10.9 Therms for the grazing cow, 12.5 Therms for the stall-fed pasture cow and 10.8 Therms for the animal in the air-conditioned laboratory. While the figures obtained are somewhat higher than those reported by Armsby (6.0 Therms), it should be pointed out that these data were obtained using fresh green forage while those of Armsby were obtained using rations of dry forage and low concentrates. The results suggest that the requirements for maintenance for a grazing cow are no greater than for a stall fed animal. The high figure for the pasture stall-fed animal probably denotes the tension of being confined to a stall while her contemporaries were grazing close by. (AH h2-7)

5. Replacement Values for Forages and Concentrates for Maintenance.

The replacement equivalents of grain and hay are not definitely established. In order to obtain some information on the replacement equivalents of these two feeds, adult, nonpregnant cows were maintained on rations having different hay to grain proportions. Eight Holstein cows were fed a ration having 1.0:0, 3/4:1/4, 1/2:1/2, and 1/4:3/4, proportion of alfalfa hay to concentrate, respectively, for periods of 120 days in an experiment of a Latin square design. Data on the last 90 days of each period were used. Subsequently, 4 of the cows were fed only the concentrate (37% soybean meal, 63% corn) for a period of over 180 days. In another trial 4 Jersey cows were fed alfalfa and concentrate in proportions of 1:0, 2/3:1/3, 1/2:2/3, and 0:1, respectively, for periods of 180 days each.

The average adjusted consumption, body weights and replacement equivalents were calculated. The average body weight for the Holstein cows decreased when the proportion of dietary concentrate increased. No correction for these changes was made when the replacement equivalents were calculated. The hay replacement equivalents for 100% grain were calculated from the averages of the animals used on this diet and weight had to be adjusted with the 2 Jersey cows using W⁷.

These calculations using data on the Holstein animals indicate that 1 pound of hay is worth about 55% of the value of 1 pound of the concentrate used. This calculated replacement equivalent was reasonably near the same for all treatment comparisons made. Data on the Jersey cows gave a similar replacement value but the value was not as repeatable between all treatment comparisons.

The replacement values obtained from these trials approximate the relationship of these two feeds when expressed on an estimated net energy (ENE) basis. The TDN and the digestible energy content was

determined using three of the cows and found to be 56.54% and 57.51%, respectively, for the hay and 82.71% and 84.64%, respectively, for the concentrate mixture used in these trials. Thus, the hay was worth 68% of the concentrate mixture when compared on the determined TDN or digestible energy basis. The ENE was calculated from the TDN value according to the formula of Moore et al., and on this basis the hay was worth 54.7% of the concentrate mixture.

It appears that the replacement values of a hay and a concentrate for purposes of maintaining body weight in dairy cows is best expressed on an ENE basis rather than on a TDN basis. (AH h2-4)

D. Calf Feeding

1. Effect of Method of Conservation on Forage Consumption of Dairy Heifers.

Alfalfa harvested simultaneously from the same field as hay, wilted silage higher in dry matter than the usual wilted silage (43-46% DM) or as direct-cut silage during 2 different crop years was fed for 2 to 3 months to growing dairy heifers 7 to 19 months of age. For each crop year there was little difference in rates of gain or dry matter intake or in efficiency of gain for heifers fed hay or wilted silage (43-46% DM). Heifers fed direct-cut silage had lower rates of gain, dry matter intake and efficiency.

In further studies, second-cutting alfalfa was harvested from the same field and preserved as direct-cut silage, wilted silage or haylage. Hay was harvested one week later from the same field. The dry matter content of the feeds was 20.8%, 34.9%, 49.8%, and 88.7%, respectively. The intake of dry matter per 100 pounds body weight for 8 days was 2.14, 2.67, 3.28, and 2.86. These data again add further weight to the evidence that one factor which controls dry matter intake of silage is the dry matter content of the crop at the time of ensiling, since the dry matter content of the feed is closely related to dry matter content of the crop at harvest. (AH h1-1)

2. Effect of Concentrates and Hay on Growth of Heifers Fed Wilted Silage.

Three methods of supplementing the wilted silage ration have been studied. Concentrates were fed at two levels, 3 pounds and 4 pounds per day and hay was fed ad libitum with the usual amount of milk and grain.

The results show that the group fed wilted silage and hay ad libitum compared to the Beltsville growth standards, were 96% of normal, those fed 3.0 pounds grain 102% and those fed 4.0 pounds 107%, while

those which received wilted silage as the only feed after 8 months of age were 81% normal. These results to date show that where wilted silage is used as the only forage after 8 months of age, that hay fed ad libitum or 3 pounds of grain per day will produce normal growth. (AH hl-1)

3. Effect of Drying High pH Silage on Dry Matter Intake of Heifers.

Previous data have shown that the reduction of the water content of silage by drying did not affect dry matter intake. The silages were good quality with a low pH, (4.5 or below). Last year a poor quality silage was available with a pH of 7.03. The silage was fed to one animal before and after drying with a dry matter intake of 7.3 pounds in the wet state and 11.0 pounds in the dry state. By drying silage with a pH of 7.03, volatile bases were probably evaporated. For instance, the ammonia content of the wet silage was 2.9% while in the dry silage it was 0.1%. These data, while limited, suggest that the presence of volatile bases in the silage may be one factor affecting acceptability. (AH hl-1)

4. Dry Matter Content and Intake of Orchard Grass Silage.

Previous experiments on the intake of silage dry matter by dairy animals has been with alfalfa silage. Orchard grass silage cut from the same field on the same day and containing 25.5 and 37.0% dry matter was compared in reversal trials of 11 days duration with dairy heifers. The results checked the previous data with alfalfa silage in that more dry matter was consumed when the silage contained 37.0% dry matter. (AH hl-1)

5. Use of Rabbits to Study Effect of Silage on Growth.

In order to hasten the study of the various factors which affect the acceptability of silage by dairy heifers, a study was made of the use of the rabbit for this purpose using growth as a measure of acceptability. The results showed that the rabbits responded in the same way as heifers. For instance, they grew considerably more on hay than on silage made from the same field.

In further experiments, I. Alfalfa silage (35% D.M.), II. Pressed silage cake (55% D.M.), III. Pressed silage cake plus the expressed silage juice (30% D.M.), IV. Chopped alfalfa hay and V. Chopped alfalfa hay plus expressed silage juice was fed to five groups of four rabbits each. The growth of groups I, II and III were similar in that they lost weight. Groups IV and V gained weight. The results show that the juice expressed by the use of a Carver press did not contain the factor which causes depression in D.M. intake in sufficient concentration to affect dry matter intake when added to a hay diet. (AH hl-1)

6. Magnesium and Cardiovascular Changes.

Where whole-milk-fed calves are not supplemented with magnesium, marked calcification of the cardiovascular system occurs. Workers elsewhere have postulated that the calcification was due to a deficiency of vitamin E in the whole milk diet. Supplementation of the whole milk diet with 50 mg. of alpha tocopherol per 100 pounds body weight did not prevent the cardiovascular lesions. While the extent of calcification may be affected by other minerals in the diet, it is concluded that magnesium is the specific deficiency which causes calcification in the cardiovascular system in calves. (AH hl-2)

7. Availability of Magnesium to Milk-Fed Calves as Affected by Various Factors.

Previous data from Beltsville has shown that the level of phosphorus in the diet of milk-fed calves had an effect on the level of magnesium in the blood serum. In the light of this observation it was decided to determine whether manganese would counteract the lowering effect of phosphorus on blood serum magnesium. When 0.43 gm. P/lb. milk was added as KH_2PO_4 blood serum magnesium values decreased more rapidly than where whole milk was fed with no supplementation. When 0.03 gm. Mn/lb. milk was added to whole milk, blood serum magnesium values decreased less rapidly than in calves fed whole milk or whole milk plus phosphorus. When both phosphorus and magnesium was added, the magnesium counteracted the effect of the phosphorus in lowering serum magnesium values. These results indicate that when calves are on a suboptimal level of magnesium (whole milk) the addition of phosphorus aggravates the situation and that manganese and additional magnesium counteract the effect of the phosphorus.

The addition of sodium or potassium bicarbonate did not prevent the decline in blood magnesium of whole milk-fed calves. The possible relation of these observations to grass tetany should be investigated. (AH hl-2)

8. Purified Diets for Calves.

For some time attempts have been made to develop suitable synthetic diets for calves so that it would be possible to produce single uncomplicated deficiencies by removal of a single nutrient such as a vitamin or mineral. Such a diet has been developed at the North Carolina Station suitable for sheep. The same diet is being tried with calves at Beltsville. Growth to 90 days of age has been about 80% normal, which is quite good for such a diet. (AH hl-3)

9. Activity of Vitamin A Acid.

It has been suggested that vitamin A acid can fulfill some functions of the vitamin A ester or alcohol but will not replace Vitamin A in the visual purple cycle in the eye. It was found with one calf, that the acid would decrease the spinal fluid pressure caused by vitamin A deficiency. It would thus appear that the acid form can perform the same function as the ester or alcohol form of vitamin A to control spinal fluid pressure in calves. Further data should be collected. (AH h1-3)

10. Raising Calves on Pasture.

In New Zealand a system of raising calves from a few days after birth on limited milk feeding and pasture has been developed. A comparison was made at Willard of rearing calves in the barn on milk, starter and hay compared to a similar group raised on milk, starter and pasture. The pasture sequence is of interest and was as follows: Ladino clover-fescue mixture in April and May (60 days), Starr Millet in June, July and August (72 days), some Coastal Bermuda also in August (20 days), soybeans in September and October (34 days), Ladino clover fescue in October (16 days) and small grain-crimson clover October through January. The pasture group gained more rapidly than the barn-fed group with gains up to 1.0 pounds per day to 122 days of age and up to 1.5 pounds from 112 days of age to 252 days of age. The preliminary results are very encouraging. (AH h3-11)

E. Management Practices, Equipment and Facilities

1. Hand Versus Machine Milking.

The study to determine the relative merits of hand and machine milking in relation to total production, persistency and mastitis was completed.

Forty first lactation Holstein cows were paired prior to freshening and assigned at random to each milking system. In the second lactation both groups were machine milked. Thus it was possible to evaluate the effects of the two milking systems in the first lactation, as well as changes from the first to second lactation when cows were milked by machine in both and when cows were milked by hand in the first lactation and by machine in the second.

During the first lactation, the hand-milked group exceeded the machine-milked group by 985 pounds of milk and 41 pounds of butterfat per cow. These differences approached significance. The hand-milked group was significantly more persistent than was the machine group (.84 vs. .79). The variation among cows in the machine group for both milk and persistency was also greater than for the hand-milked cows.

During the second lactation when both groups were milked by machine, no differences were found in total yield, standard deviation of yield or persistency.

Sixteen hand-milked cows had both first and second lactations. The standard deviation of milk yield increased by 2,030 pounds when these cows were machine-milked. This indicates considerable variation among the hand-milked group in their response to machine milking, and suggests the change to machine milking adversely affected some cows. In fact three of these cows produced less in their second lactation than they did in their first. Also three of them dried off before completing a 305 day lactation. There was a significant decrease in persistency of 15% between the two lactations, which is approximately 5% greater than is normally expected. In addition there was a significant increase in the standard deviation of persistency.

Eighteen machine-milked cows had both first and second lactation. There was a significant increase in total yield between the first and second lactations. This increase (+2,209 lbs.) was greater than the increase between the first and second lactation of the hand-milked cows (+1,424 lbs.). The increase in the standard deviation was not significant. The 10% decrease in persistency between the two lactations was significant but in line with what is normally expected between the first and second lactations.

Repeatability estimates were determined for both total yield and persistency for the two groups. The repeatability of milk yield was 0.36 for those cows milked by hand in the first lactation and by machine in the second, as compared to 0.54 for those cows machine-milked in both lactations. The repeatability of persistency was 0.0 for those cows milked by hand in the first lactation and by machine in the second, and 0.11 for those cows milked by machine in both lactations; neither of which were significant. The estimates reflect the differential response of the hand-milked cows to machine milking.

Another objective of this study was to determine if systems of milking had any influence on the incidence of mastitis. Three of the twenty cows milked by hand in the first lactation showed clinical symptoms of mastitis. Seven of the twenty milked by machine showed clinical symptoms. Even if these differences were real, the incidence in both groups was too low and the number of animals too few to warrant testing for significance. In the second lactation, the incidence of mastitis was six out of sixteen and five out of eighteen for the two groups, respectively.

These results show an adverse effect on total production when cows are milked by machine as compared to milking by hand. They also show a large amount of variation among cows in their response to machine

milking. The results suggest that if changes occur in the milking systems during the period of an experiment appropriate corrections should be made before the production data are summarized. In view of present day practices this problem will probably be of no importance in future research. However, it has an important bearing on the analysis of data from breeding research that covers a period when such changes could have occurred. (AH g3-9)

2. Electrically Controlled and Operated Equipment for Reduction of Labor in Dairy Production.

In cooperation with the agricultural engineers, a comparison of labor and time was made between three systems of milking. These systems were: (a) A portable bulk tank, (b) a dump station and (c) a regular routine.

The portable bulk tank was a rectangular stainless steel vacuum tank capable of holding 150 gallons of milk. The milk was cooled by a $1\frac{1}{2}$ horsepower refrigeration unit attached to one end of the tank. The tank was mounted on wheels and was self-propelled by a $1/3$ horsepower gear motor and steered by a hand lever. Cows were milked directly into the tank by two milking units. Equipment for supplying vacuum to operate the milking machines was also part of the system.

The dump station consisted of a milk receiving vessel and a plastic pipeline with enough hose to transport milk 200 feet. This system operated under vacuum and required a releaser at the opening into the bulk milk tank.

The regular system followed the conventional practice of carrying the milk in pails to the milk house and dumping the milk by hand into the bulk tank. The milk house was located an average distance of 50 feet from the cows.

Two operators, eleven cows and six milkings per operator were used to evaluate each system.

Average total time required to milk eleven cows was 51.0, 40.7, and 43.1 minutes for the portable bulk tank, dump station and regular routine, respectively. The longer time for the portable bulk tank was due mainly to more idle man time, idle machine time and time for re-positioning the equipment. The reason for this was that cows were milked in groups of four each and then the tank was repositioned behind four other cows before they could be milked. The disadvantage for the regular routine was in carrying the milk to the milk house. On eleven cows, this operation required a total of 6.60 minutes.

Significant operator differences occurred in the following time elements: Preparation, idle men, stripping and transferring the milking units.

Eight of the fourteen elements showed significant system by operator interactions indicating that different operators reacted differently to the three systems of milking. The interactions consisted of variation in magnitude of the differences between systems from one operator to another. There was no change in rank of the systems among the operators.

The use of the dump station showed the most labor advantage. This advantage would increase with increasing distances from the cows to the milk house. Milk could be transported much farther than the 50 feet indicated in this study. Under conditions of small herd operations, labor might not be as important a factor as the investment in equipment. When this occurs the portable bulk tank might be advantageous. Acceptance or rejection of a system should be based upon the investment in equipment as well as the labor necessary to operate it. (AH g3-10)

3. Bovine Mastitis.

A study was made to determine if there were inherent differences among cows in their resistance or susceptibility to mastitis organisms. Analysis of milk sample data was made from 373 cows in a second lactation and 235 of the same cows during their 3rd lactation. These were data from a 12-year period of sampling milk from all cows during the first 3 months of lactation and taking additional samples whenever strip cup flakes or other mastitis symptoms suggested the possible presence of mastitis organisms.

Eighty-five percent of the cows that showed organisms during the early part of their lactation were clean at the end of lactation. This percentage was the same for cows that were clean during the early part of lactation. However, of the cows that showed organisms periodically throughout their lactation, only 23% were clean at the end of lactation. These results do not show that resistance to organisms is developed when a cow is infected.

The possible repeatability of susceptibility to mastitis infections from one lactation to another was studied from the milk samples obtained from 238 cows in both second and third lactations. Cows were divided into three groups according to the incidence of infections in the second lactation.

In the third lactation, infecting organisms were found in 67.7% of the 99 cows free of infection in a second lactation, 59.2% of the 76 cows infected but later cleared in a second lactation and 68.3% of the 60 cows infected but not cleared when last sampled in a second lactation. These percentages give no indication that susceptibility or resistance to organisms in one lactation indicates what may be expected in the subsequent lactation. (AH g3-8)

4. Antibiotic Detection.

A study was made in cooperation with Eastern Utilization to determine the desirability of using chlorophyll as a marker in detecting the presence of penicillin in milk. Two trials were conducted using four cows with different levels of production (range 13 to 60 pounds of milk per day). Chlorophyll levels of .3, .4, .5, and .6 gms. were mixed with 100,000 units of penicillin in 10 cc carrier and injected into each quarter of each cow. Both penicillin and marker were assayed each milking. The penicillin could be detected at a level of .02 units per ml. of milk up to an average of 6.26 milkings from the time of injection. No differences occurred in penicillin level between trials, marker levels and quarters. Differences were significant between cows with the higher milk level cows ejecting the penicillin before the low level cows.

The presence of the marker was evaluated on a visual basis and with ultraviolet light. An average of 6.51 milkings was required before the marker could not be detected upon visual examination and 7.51 with ultraviolet light. For both methods of detection no differences were found between trials and between marker levels. Differences did occur, however, between cows and between quarters. The lower producing cows and the front quarters retained the marker longer than the high producing cows and the rear quarters.

Correlations were determined for each milking and overall milkings between penicillin and marker levels. At the sixth milking (the approximate time both marker and penicillin had left the udder) the correlations were .73 for visual detection and .64 for ultraviolet detection. The correlations for all the milkings were .81 and .81, respectively. These results indicate that chlorophyll would be quite effective as a marker to detect penicillin in milk.

Another study was conducted using Green 3 and Blue 1 dyes along with chlorophyll. Two gm. doses of the dyes were mixed with .05, .10, .20, and .25 gms. of chlorophyll and 100,000 units of penicillin. These preparations were injected into four different cows, with each quarter receiving a different solution. Two trials were conducted. Penicillin stayed in the udder 6.33 milkings after injection. The chlorophyll could not be detected upon visual examination because of the masking effect of the dyes. However, ultraviolet detection was possible up to 7.35 milkings after injection. The dyes could be detected upon visual observation up to 4.79 milkings after infusion. Significant differences were found between cows, with higher producing cows eliminating the dyes before low producing cows. Rear quarters eliminated the dye faster than front quarters. The green color stayed in the udder longer than the blue color. These results suggest a helpful means for the farmer to keep penicillin out of his milk by visual detection of a dye. They also suggest the use of chlorophyll as a means by which milk plant

operators can detect penicillin and thus prevent its being incorporated into the milk supply. (AH g3-7)

5. Antibodies in Milk.

The purpose of this work is to determine if absorption and/or protection occurs when milk containing antibodies is ingested by humans or livestock. Experiments with calves were designed to duplicate those of Sarwar and Peterson at Minnesota.

Ten calves were used in an attempt to establish a minimum lethal oral dose of the live bacteria (E. Coli #158). The bacteria were given in 50 ml amounts as saline suspensions by use of a tube passed into the esophagus. Doses containing as high as 9.3×10^9 live bacteria per ml were given but none of the calves became sick or died. The highest doses used were approximately four times as large as those used by the Minnesota workers.

Eight calves were used to determine the effect of intravenous injections of the live bacteria. Results showed that 4×10^9 or more live E. Coli #158 would cause death in a few hours. Based on these results the intravenous route was chosen as the method of challenge for the protection experiments. Eighteen one-month-old calves were paired on the basis of age and one of each pair was fed approximately 14 pounds per day for five days of milk containing antibodies against E. Coli #158. This milk was obtained from cows that had been infused with heat killed E. Coli #158 for several weeks prior to freshening. Serological tests on the milk from these cows after they freshened showed the presence of antibodies against E. Coli. The control calf was continued on the regular diet of herd milk. Two of nine calves fed milk with antibodies survived as compared with one of nine control calves.

All calves were bled at birth and tests were made to determine the presence or absence of antibody against E. Coli. None of 23 calves bled before nursing had antibodies against E. Coli #158. Sixteen of 32 calves that received their dam's colostrum had antibodies against E. Coli #158 at one week of age. Titers varied from 4 to 512 at this time. Four of the dams had been infused with the organism to stimulate antibody production and their calves generally had the highest titer. Serological tests were continued at weekly intervals up to four weeks of age and the titer dropped gradually in all cases. Most calves were negative by three weeks and only four of the sixteen originally having antibodies still had a titer at four weeks. Antibodies were not found in the serum of any of the ten, month-old calves fed milk containing them. These results fail to confirm those of the Minnesota workers who reported that antibodies fed in the milk could be detected in the serum and that they could protect calves against challenging doses of live E. Coli #158. Additional work is being done to determine

whether extracts of the antibody milk can protect the calves if given by injection.

In cooperation with the Urology Department of the U. S. Naval Medical Center at Bethesda, antibody milk has been prepared against bacteria isolated from two patients with chronic urinary tract infections. Proteus mirabilis was the organism isolated from one patient and a heat killed suspension of the organism was used for the infusion into two cows. The culture from the other patient contained Proteus mirabilis and E. Coli and the mixture of these two was infused into two cows. The procedure for the infusions was the same as indicated above for E. Coli #158. When the cows calved, milk was sampled, pasteurized and frozen in one quart containers. The antibody titer in the different batches of milk that were processed in this manner ranged from 1:80 to 1:640. However, samples from individual milkings were occasionally much higher. The two patients were put on a twice weekly examination schedule at the hospital. At each visit a blood sample was taken for serological study. Urine was examined for pyuria and the urologist examined the patient. Each patient was given a supply of normal, pasteurized herd milk frozen in one quart containers and instructed to drink a quart a day--a pint at a time. After consuming this milk for two weeks the patients were switched over to antibody milk from the cows that received their respective organisms. The patients did not realize that the first milk did not contain antibodies. One patient drank the antibody milk for one month without detectable effects on his clinical condition or the level of antibody in his serum. The other patient drank antibody milk for six months. There has been no significant change in his condition that could be attributed to the antibody milk. His condition has generally improved but the improvement is considered due to drugs, especially since there was no exacerbation of symptoms during the two months since this patient stopped receiving antibody milk. Serological tests on the serum of both patients indicated the presence of antibodies against the specific organisms involved. The titer varied from time to time but could not be related to the drinking of the milk since the titers did not change at least up to six weeks following cessation of the milk in the one patient studied most extensively.

Another attempt was made to determine if antibodies can be taken orally and pass into the blood in humans. Ten adult males in apparent good health were bled to establish antibody levels, if any, in their blood. Each man drank a quart a day (pint at a time) of antibody milk for seven days and each was bled on the seventh day. Six of these drank milk containing antibodies against Proteus mirabilis and E. Coli. Tests of the before and after blood samples failed to give any evidence whatsoever of uptake of antibodies into the blood. (AH gl-8)

6. Influence of Management Practices and Environmental Factors on Adaptability.

These investigations involve the determination of the effect of environmental influences, including climatic elements, on dairy cattle adaptability and the evaluation of management practices on the performance of dairy cattle in hot and humid regions. This work is cooperative with the States of Georgia, Louisiana, and Texas. Some of the studies are also in cooperation with the Agricultural Engineering and Animal Disease and Parasite Divisions. These projects contribute to the Southern Regional Dairy Cattle Breeding Project, S-49.

Efforts to characterize the response of lactating Jersey cows to a shelter versus no shelter during the summer and winter periods have been conducted for three years at Tifton, Georgia. For the summer, shades constructed of galvanized iron painted white on top were provided both at and away from the feed bunks for the shade group. A similar adjacent area without shade was used for the no shade treatment. In the summers of 1958 and 1959 shade versus no shade for lactating Jersey cows were compared. No difference in milk production was found between the two groups. In 1960 shade was compared to shade plus fans. The fans were used to decrease the humidity caused by the assembling of the animals under the shade. Although the milk production of fan plus shade group was slightly higher than for shade alone, there was not sufficient difference to warrant the additional cost. In 1961 sprinklers were added to shade plus fan lot. The sprinklers were set out separately from the shade over a concrete slab which had been tinted green to reduce surface radiation. The cows had free choice to the sprinkler but did not seem to relish the sprinkler until it was covered. The cows with the sprinkler showed less rise in body temperature, produced slightly more milk (1.5 lb./da./cow) and consumed more dry matter than cows with shade alone. Although not statistically significant, this is the largest difference that has been obtained thus far and may have been more pronounced had the sprinklers been covered for the entire period.

The summer observations of milk production, feed and water consumption and rectal temperature collected over the three-year period (1958-1960) were used to appraise the relative influence of climate on dairy cattle response. The weather measurements and cow responses were separated into 31 independent and 15 dependent variables, respectively. The climatic variables most highly correlated with cow response were average temperature 1100 hr. bulb dry temperature and maximum temperature. The influence of the independent variables, including year and lactation decline, on cow response was estimated by multiple regression. Of the variation observed in milk production and feed consumption, 94 and 40%, respectively, could be attributed to the combined influence of the independent variables. Even so, examination of partial regression coefficients revealed that climate had a greater influence on feed

consumption than on milk production. After correcting animal performance data to a common year for treatment and stage of lactation, only 11 and 23% of the variation in milk production and feed intake, respectively, could be associated with variation in climate. Of the weather variables considered, the single variable having the greatest influence on feed intake and milk production was daily maximum temperature. Simple correlations between a.m. and p.m. cow performance and weather variables indicated that during stressful weather, it is especially important that cows have ample quality feed available both day and night.

In the winter studies, the shelter used during the summer was closed on three sides with plastic sheeting supported on a woven wire frame. The same adjacent lot with no protection was used for the nonshelter treatment. Daily averages of day and night dry bulb and minimum temperatures were 60, 54, and 45° F., respectively, in 1959 and 55, 48, and 38 for 1960. In 1959 the average daily milk yield for the shelter group was 29.6 and 31.5 for the nonsheltered group. Corresponding figures for 1960 were 23.9 and 25.5 pounds per day. Respective average regressions of pounds of milk per cow per day of test for the sheltered and nonsheltered groups were -.060 and -.079 for 1959 and -.078 and -.023 for 1960. The more rapid decline in production of the sheltered cows for 1960 was attributed to differences in dry matter intake. When the body temperatures of the animals dropped due to inclement weather, the nonsheltered cows attempted to compensate through increased feed intake while the sheltered group attempted to prevent a drop in body temperature by remaining under the shelter.

It is recognized that daily climate is best described by using continuous weather observations, but generally this is not practical. In a study of single versus frequent observations for estimating some summer climatic conditions in Southern Georgia, all possible correlations were computed between vapor pressure, dew point, wet bulb temperature and dry bulb temperature at 0800, 1100, 1400, 1700 and also an average of readings at these hours, plus daily solar radiation, hours above 80° F. and maximum temperature. Correlations indicated that wet bulb more satisfactorily measures humidity than dew point or vapor pressure. The correlation of .87 between wet bulb at 1100 and average wet bulb indicated that wet bulb at 1100 is probably the best single measure of humidity for the daytime period. Maximum temperature, solar radiation and hours above 80° F. are related to daytime dry bulb temperature. Of the dry bulb readings, that for 1100 had the highest correlation (.85) with average dry bulb. Correlations of 1100 dry bulb with solar radiation, hours above 80° F. and maximum temperature were .53, .70, and .84, respectively. The best single measure of daily temperature conditions seemed to be 1100 dry bulb. The best two observations for evaluating the daily climate conditions appeared to be dry bulb and wet bulb at 1100 while the best single observation was 1100 or 1400 dry bulb and next was maximum temperature.

Studies of the value of various materials for shade roofing at Louisiana State University have shown that galvanized iron or aluminum painted with white plastic are equally good in reducing solar radiant heat, and superior to polished or nonpolished aluminum, galvanized iron painted with aluminum or plain galvanized iron.

At Louisiana State University, the mean grazing time for Holstein cows during July was 6 hours and 16 minutes per day. The cows did 65% of their total grazing during the day. Mosquitoes became a serious impediment to night grazing. The animals grazed most during the early morning and late afternoon. Among the different climatic components studied, solar radiation appeared to have the most pronounced effect on physiological responses and grazing behavior. This was followed by air temperature, wind velocity and humidity in that order. From this study it appears that lactating cows should be allowed to graze in the early morning and late afternoon with an interim of supplemental feeding. (AH g4-3)

7. Environmental Influences Affecting Production Records.

This project was initiated to develop methods for minimizing the environmental influences on production records and thus improve the records as estimates of genetic merit. The work is carried out at Beltsville, jointly with the Dairy Herd Improvement staff of the Dairy Cattle Research Branch and in cooperation with the Wisconsin Agricultural Experiment Station.

At Wisconsin production and environmental data were collected by 17 DHIA supervisors, project fieldmen and project personnel. Fifty project herds in 5 Southern Wisconsin counties were visited.

Repeatability of various personnel in the evaluation and reporting of environmental data was determined from reports by the three groups of persons. The DHIA supervisors and the project fieldmen were not repeatable with each other in recording herd management ratings which were nonobjectively defined. The project fieldmen and other project personnel were repeatable with each other. With one exception the DHIA supervisors, the project fieldmen and the four other project personnel were repeatable to each other in the evaluation of roughage quality through the use of a descriptive score card. It is likely, as shown by these results, that the pounds of hay and silage and percentage of crude protein on a herd basis and weight by tape on an individual cow basis are reliably reported by DHIA supervisors.

Simple correlations were obtained between herd production and the ratings given by the various personnel to milking practices, housing and cow comfort, disease and injury, housing and care of calves, housing and care of heifers, general farm appearance, condition of

herd and herdsmanship. It was concluded that when the management ratings are considered as a group those reported by the project fieldman and the project personnel were similarly associated with herd production. However, those reported by DHIA supervisors were associated with herd production to a lesser degree. The project personnel did not know the herd level of production at the time of the farm visit.

An effort was made to determine the feasibility of using mark-sense and porto-punch in the recording of DHIA data under field conditions. Five project herds serviced by 5 DHIA supervisors were used for 7 months in the trial.

This study showed that the mark-sense method required less extra time and equipment and could be used more easily and accurately in the field than the porto-punch method. There was no appreciable difference in the two methods at the machine processing center. The existing barn sheet method appeared to be superior in accuracy to either mark-sense or porto-punch method. The major problems in the use of either of the card systems, discounting the possible decrease in accuracy, were training and supervising DHIA field personnel and the vast amount of card shipments to and from the field each month. Estimates of costs with porto-punch or mark-sense methods would be from two-thirds to three-fourths the cost of the present barn sheet method when mailing costs are included. While it appears possible to utilize mark-sensing as a method of recording standard DHIA data and thus reduce the cost of machine processing, it is doubtful if it would be practical under existing conditions of fieldman supervision. The mark-sense method appears to have a real potential in the collection of data by trained personnel such as this project's fieldman.

Studies are in progress to determine the relative accuracy of four laboratory methods of estimating nutritive value of hay through the use of 49 test samples having "in vivo" digestion values. The laboratory methods compared were Morrison's digestion coefficients used in estimating TDN, Pennsylvania State's formula based on crude fiber and crude protein, the Snyder-Lucas regression equation using crude protein, crude fiber and NFE, and an artificial rumen or cellulose digestion procedure. The work was carried out in order to determine which method of estimating nutritive value of hay would be most reliable in testing the hay scorecard.

The correlations between the cellulose digestion values and the "in vivo" digestion values were approximately .71 when estimating TDN or digestible energy. These correlations were considerably higher than those found for any of the other three methods. Therefore, it appears that cellulose digestion as determined by artificial rumen studies provides the best estimate of useful energy in hay and should be used in testing hay scorecards.

A study was made to determine the influence of some environmental and physiological factors on the California mastitis test. This test was conducted once on 1,417 cows with 5,612 milking quarters in 45 co-operating project herds. A total of 60.3% of the cows and 30.6% of the quarters were classified as positive. There was a marked increase in the incidence of inflammation with increasing lactation age. While monthly fluctuations existed, a general increase in percentage of positive quarters occurred during lactation with a low of 18.6% in the 1st month and a high of 39.6% in the tenth month. As daily milk yield declined, the percentage of positive quarters increased from 27.2 to 43.1%. Significant relationships were found between the California mastitis test and man time per cow, line vacuum fluctuations, deviation in pulsation rate, overall sanitation score and yearly butterfat average.

Ease of milking ratings were made on each cow in 45 of the project herds. Each cow was scored very easy, easy, hard, or very hard. The relationship between maximum rate of milk flow and ease of milking, when stage of lactation, lactation number, daily milk yield and age was held constant was 0.355. An estimate for heritability of ease of milking and California mastitis test were computed as .58 and .36, respectively.

A study of 111 management variables and their association with production was made. Those variables having significant relationships with milk yield were: housing and cow comfort, mastitis prevention and control, housing and care of calves, and herdsmanhip. The 19 management practice variables which were most highly correlated with herd production accounted for 69% of the variation in milk yield. (AH g5-1)

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AREA NO. 8 - POULTRY - BREEDING

Problem. Poultry breeders have made greater use of current genetic knowledge than any other group of livestock breeders. So widely have new principles been adopted in the industry that many breeders question whether further progress is being made in improving certain traits. They believe that the useful genetic variation already may have been exhausted. Information is needed as to the relative rates of progress which will result from various breeding systems for improving economic traits such as egg and meat production, respectively. Are different systems required at different stages in the breeding program? Knowledge is required on the heritabilities, genetic correlations and gene-environment interactions, and the consequences of selection on these parameters, in order to design the most efficient breeding systems. Information on the physiological basis for the action of certain genes would lead to a better understanding of controlling heredity for optimum performance. Also, economics of production should be improved through basic knowledge on the genetic aspects of feed utilization efficiency and of various stresses during selection.

USDA PROGRAM AND RELATED PROGRAMS OF
STATE EXPERIMENT STATIONS AND INDUSTRY

This is a continuing long-term program involving basic studies of the inheritance of egg production and broiler characteristics. Much of the research is conducted within the framework of four regional projects. In addition to financial aid to several of the State contributing projects and major contributions to the establishment and maintenance of central facilities, the USDA also provides coordinating personnel located at Athens, Georgia; Lafayette, Indiana; and Beltsville, Maryland. The close working relationship between the USDA and State experiment stations in the four regional projects provides for integrated research on a large scale without duplication of effort. The major emphasis in the North Central region is on egg production traits and the research is done at the Regional Poultry Breeding Laboratory, Lafayette, Indiana, and at 12 cooperating State experiment stations. In the Southern region the major emphasis is on broiler traits and the work is conducted at the Southern Regional Poultry Genetics Laboratory, Athens, Georgia, and at 14 cooperating State experiment stations. The work in the Northeastern region involves the improvement of chickens through genetic and physiological studies and is conducted under cooperative projects at 11 cooperating State experiment stations. Cooperative work on turkeys is carried on with six Western States. Work at Beltsville, Maryland, involves the study of the inheritance of egg

and meat production traits. The work on performance testing and disease control, in connection with the National Poultry and Turkey Improvement Plans is carried on with cooperating Official State Agencies in 47 States.

A Research and Marketing Act contract with Purdue University Agricultural Experiment Station provides for a study of the genetic statistics of inbred poultry lines and their combination in single crosses, four-way crosses, and top-crosses. This two-year study utilizes data accumulated from the North Central Regional Poultry Breeding Project and will be completed in 1963.

During the past 12 months seven USDA line projects were terminated and two new ones were initiated.

A total of 10.2 professional Federal man-years are devoted to this program annually. Of this number 4.6 man-years are devoted to genetics and interrelations of performance traits, 3.0 to performance testing, 1.5 to selection and systems of breeding, and 1.1 to program leadership.

State experiment stations reported a total of 43.3 professional man-years of which 20.2 are included in regional projects and 23.1 are for nonregional research. The 43.3 man-years are divided among the subheadings as follows: genetics and interrelations of performance traits 18.0, performance testing 3.9, selection and systems of breeding 21.4.

Industry and other organizations are very active in the field of poultry breeding. Fairly accurate estimates of the number of professionally trained geneticists or those with the equivalent experience who work for industry and other organizations in poultry breeding are possible. Egg breeders employ approximately 26, broiler breeders 14, and turkey breeders 6, on a full-time basis. In addition, there are other organizations that make some attempt to improve poultry and it is estimated that egg breeders of this type devote the equivalent of 18 professional man-years, broiler breeders 5 professional man-years, and turkey breeders 4 professional man-years. Taken all together it is estimated that 75 man-years of effort go into research by commercial poultry breeders. Almost all of this private research is developmental in nature. Occasionally one or two of the larger organizations have research which is published in scientific journals.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Genetics and Interrelations of Performance Traits

1. Genetic Aspects of Nutritional Deficiencies.

Selection for fast and slow growth on a methionine deficient diet indicates that lines can be developed that differ significantly in their ability to utilize a diet deficient in one of the essential amino acids. Analysis of variance shows a highly significant difference between lines but no difference at 3 weeks due to sex or sex x line interaction when fed the deficient diet. The lines did not differ when fed a commercial broiler ration from hatching to three weeks of age. Chicks from the F-line were generally about 50% heavier at three weeks of age than the S-line chicks when fed the methionine deficient diet. It was noted that the F-line laid somewhat earlier but when a production peak was reached the rate of lay was almost identical in the two lines. Egg weight was approximately two grams per egg greater in the F- than in the S-line. The two lines did not appear to differ in either fertility or hatchability. There was no consistent difference in mortality between the lines. (AH el-44)

2. Gene-Environment Interactions

Gene-environment interaction studies involving both egg and meat production, were conducted as part of the Southern Regional Poultry Breeding Project. In one instance egg production stock and in the second, meat production stock were hatched in Athens, Georgia. The chicks were shipped to cooperating State experiment stations and all were started on feed at the same time.

Three trials of the meat phase were concluded during the reporting period. Ten stocks were reared at eight locations and 2-, 4-, 6-, and 8-week individual body weight and mortality data were recorded. An analysis of variance based on means indicates highly significant differences (1% level) for all main effects (location, source, sex, and trial) at 2, 4, 6, and 8 weeks. This is also true for all first order interactions except for source x sex, which was nonsignificant at two weeks. All second order interactions were nonsignificant except location x sex x trial at 2 weeks and location x source x trial at 2, 4, 6, and 8 weeks which were significant at the 1% level. Two gene-environment interaction studies involving 10 different egg laying stocks reared at nine cooperating State experiment stations and the Regional Laboratory have been completed. The data are being analyzed but preliminary observations indicate considerable variation in performance with respect to source and location. (AH el-44)

3. Egg Quality Traits.

A study involving egg production and various egg quality traits in White Leghorns was concluded at Beltsville. Results indicate high negative genetic correlations of $-.608$ between egg number and Haugh units and of $-.568$ between egg number and albumen height. (AH el-30 Rev.)

The degree to which albumen quality loss in storage is heritable and its relationships with other economic traits were studied at the North Central Regional Poultry Breeding Laboratory. The heritability of Haugh unit loss between the time of laying and the end of a two week storage period was $.225$ (additive) and $.31$ (nonadditive). The heritability of both Haugh units fresh and stored was $.61$ for additive effects and $.13$ and $.24$, respectively, for nonadditive effects. A genetic correlation of -0.87 between Haugh units loss and the ratio of the stored Haugh unit value to the fresh Haugh unit indicates little difference exists between these two methods for measuring albumen quality loss. Since Haugh units stored was found to be highly correlated with the trait, percent stored of fresh Haugh units, and has a higher heritability and genetic standard deviation, it appears to be the most logical trait to use in selection for better albumen quality at the point of consumption. Egg size and albumen quality were highly and positively correlated due to additive effects, but negatively correlated due to nonadditivity. Genetic correlations between body weight and albumen quality loss were similar to the above. High egg production and early sexual maturity were associated with poorer egg quality. (AH el-43)

4. Genetic Variation in Economic Traits.

An experiment with White Leghorns to increase summer egg production under arid, semitropical conditions at Glendale, Arizona, was completed after seven years of study. Highly significant differences were demonstrated between the preceding 8 months of egg production and the 4 months of summer production, and between years and birds for both of these factors. The phenotypic correlation between the 8-month period and the 4-month summer period was $.52$. The interaction between the preceding production and summer production varied between years and this source of variation was highly significant. Breeding for improved summer production, by selection on the basis of the summer rate of production was successful. (AH el-1, Rev.)

The inheritance of economic traits in the Regional Cornell control population was studied at the North Central Regional Poultry Breeding Laboratory. Heritabilities due to additive effects were 0.26 for age at first egg, 0.62 for 32-week egg weight, 0.62 for 32-week body weight, 0.06 for percent production to January 1, 0.16 for percent production to 72 weeks of age and 0.10 for albumen score in June. Consistently higher estimates of heritabilities from the dams' variance components than the sires' indicated maternal effects for age at first egg,

32-week egg weight, 32-week body weight, percent production to 72 weeks and USDA albumen score. Dominance effects were important for age at first egg, egg weight, body weight, percent production to January 1, percent production to 72 weeks and USDA albumen score. The genetic correlations between egg weight and egg production and between egg production and albumen quality were negative. These results emphasize the complexity of the inheritance of economic traits and help to explain the difficulties which apparently have arisen in maintaining progress in selection programs. (AH el-43)

Virginia workers have noted that breast angle differences between lines have increased in each of three generations of selection for broad and narrow breast angle at 8 weeks of age. Genetic, phenotypic and environmental correlations computed for females between breast angle at 8 weeks of age and body weight at 4, 8, 24 and 38 weeks indicate that at younger ages the environmental correlations between breast angle and body weight were of greater magnitude than the genetic correlations. Body weight at 24 and 38 weeks of age appeared to be affected very little by 8-week breast angle. This would indicate that artificial selection for or against broad breasts at 8 weeks of age would not result in large changes in body weight at older ages. Texas workers found a negative correlation of 9-week body weight and 9-week breast width. (AH el-44)

Analysis of selection differentials at Washington indicate that selection for large body weight in turkeys reduces hatchability of fertile eggs, and conversely, selection for high hatchability reduces body weight. Realized heritability in the three selected lines for their respective traits were .28 for the growth line, .08 for the egg production line and .40 for the hatchability line. (AH el-46)

5. Genetic Effect on Physiological Traits.

At the North Central Regional Poultry Breeding Laboratory, repeated blood transfusions from Regional Red or Black Regional Dominant hens into White Leghorn hens or from White Leghorn or Black Regional Dominant hens into Regional Red hens administered over three generations failed to produce changes in the inheritance of the feather color of the progeny of the transfused hens. These results are in contrast to earlier Russian reports of changes in feather color genotypes produced in the progeny of transfused White Leghorn hens. (AH el-43)

Research with blood antigens at the Texas and North Carolina stations indicates that certain blood group systems are involved in resistance to fowl typhoid and in hatchability of fertile eggs. The Texas workers found heterozygosity advantageous at some loci but an advantage for the homozygous condition at one locus. (AH el-44)

Research on blood pressure of chickens at New Jersey shows that the two lines developed for high and low blood pressure, respectively, have continued to separate but that the productive performance has not been consistent. However, the hypotensive birds are generally more susceptible to certain physical stresses than the hypertensive ones. (AH el-45)

Studies involving serum cholesterol levels in chickens at Maryland indicate that while the serum cholesterol level varied in the two lines selected for high and low levels, respectively, there was actually **very** little difference in the yolk cholesterol of the two lines. (AH el-45)

In a study in which skin from various strains and crosses was grafted onto White Leghorn and Rhode Island Red hosts, the Kansas station has shown that effective differentiation by means of the severity of the skin-graft reaction could be made between pure strain donors which were from the same strain as the host, crossbred donors which had a breed in common with the host and crossbred donors which had no breed in common with the host. Sex-linked genes appear to be important in the graft reaction since female crossbred donor tissue containing the x chromosome of the breed other than that of the host, was rejected more rapidly than tissue from female donors of the reciprocal cross. In all studies Rhode Island Red hosts rejected homografts more rapidly than White Leghorns and older chicks sloughed their grafts more rapidly than young ones. That the Bursa of Fabricius is involved in the development of antibodies against the grafts was indicated by heavier Bursas in the grafted hosts compared to the nongrafted controls. (AH el-43)

B. Performance Testing

1. Improving Design of Performance Tests.

Cooperative research with Iowa State University under a contract arrangement was initiated in order to develop improved procedures for testing the performance of poultry.

The first Iowa on-the-farm test consisted of 12 entries tested at 5 farms in a lattice design. The second and third tests involved 16 entries tested on 16 farm units in a quadruple lattice design, which was a more efficient design than the first. Detailed procedures for analyzing results obtained in these designs were developed and the performance data were analyzed with these analytical methods.

The results of this study covering three years of performance testing indicate that genotype x environment interactions of the Entry x Farm type are important for age at sexual maturity, laying house mortality, rate of egg production, egg size and housing body weight. Entry x Farm interaction effects appear not to be important for final body

weight, pullet growing mortality and egg quality measures of performance. The Entry x Farm interaction effect is confounded with the main effect due to entries when comparisons are made at the same test location. This is a source bias which causes an overestimation of entry differences. In the 1959 data this bias amounted to 11% and in 1960 over 33% of the entry variance in the performance index.

Parent-flock source effects may also bias entry comparisons. This is apparently of some importance when each entry originates from a single parent flock. Parent-flock source variance amounted to 13% of the entry variance in the performance index in each of the two years where it was possible to isolate this factor for investigation.

The most efficient test appears to be a multiple location, single-pen, replication type where the entry samples are derived from more than one hatchery or parent flock source.

Coordination of random sample tests has passed from the experimental phase to a regular procedure now to be carried on by the Poultry Improvement Staff, under its Work Project (AH e5). The Poultry Improvement Staff arranges to gather the data from the various State tests, prepares the data for analysis and has it processed by Biometrical Services. Wide dissemination of the combined results is being achieved through an ARS series of publications. (AH e1 35(c))

2. Random Sample Performance Tests.

The results of random sample performance tests have become an important source of information for the use of poultrymen in evaluating the performance capacity of commercially available poultry stocks. The tests terminating in 1961 reported results for 694 entries representing 288 stocks, of which 184 were entered in egg production tests, 52 in broiler tests, and 52 in turkey meat production tests.

The results reported by the egg production tests for 15 traits were combined by stocks and the regressed means computed for each trait for each stock. These computations take into account the repeatability between tests, the number of tests entered, environmental or nongenetic differences between tests, and the level of performance within each test in relation to the other stocks entered. The results of these computations are published in annual summaries which are made available for general distribution. The 1960 and 1961 summaries also included the LSD Range for each regressed mean of each stock. The LSD Range is based on the computed least significant difference at the .05 level of probability and is included in the published summary as an aid to the interpretation of the data.

A combined analysis was made of the results reported by 4 broiler tests in 1961. This analysis indicated that, because of certain weaknesses

in the testing procedures, the combined results would not support valid comparisons and the publication of a combined summary of broiler test results has been postponed.

The results submitted by each of the turkey tests in 1960 and 1961 were analyzed separately. The results of each entry for 24 traits and the application of Duncan's multiple Range Test to 12 of these traits were published in annual summaries. The 1961 test data from all turkey tests were also combined by stocks and the regressed mean and LSD Range for each of 9 traits for each stock were included in a supplement to the 1961 turkey test summary. (AH e5)

3. National Poultry and Turkey Improvement Plans.

It is estimated that about 3/4 of the chicks and poults produced during the last 2 years were from the 2500 hatcheries participating in the Plans. These hatcheries, with capacity for more than 400 million eggs, used only eggs from breeding flocks which were classified under National Plans standards. All of the flocks, composed of more than 40 million birds qualified for a disease control classification and more than 90% also qualified for a breeding classification. Most of the flocks qualified for a breeding class on the basis of physical selection standards. However, the number of flocks classified on the basis of the stocks' performance in random sample tests was substantially greater than in previous years.

The incidence of pullorum and typhoid, as indicated by the number of reactors on first test, have reached a low level at .012%. In order to accelerate further reduction in these infections, work has been started on the development of an air analysis procedure to detect infection in the hatchery. Also, during the past year the procedure for reporting and investigating pullorum and typhoid "breaks" was expanded with a view to reaching previously undisclosed sources of infection. The expanded system involves the cooperation of the Official State Agencies, diagnostic laboratories, State disease control agencies and the ADE field offices.

All shipments of hatching eggs, chicks and poults by Plan participants to points outside the United States are accompanied by a special report (NPIP-15F) on the type and purpose of the stock. This report is intended to clarify misunderstandings which have resulted in the misuse of the stock and subsequent dissatisfaction of the purchaser. Such reports were made for more than 87 million hatching eggs, chicks and poults shipped to 63 countries last year. (AH e5)

C. Selection and Systems of Breeding.

1. Evaluation of Genetic Changes Produced by Various Breeding Systems.

Thirty-nine samples of various breeding systems under study throughout the North Central Region and certain crosses between them were compared with their base control populations for more than 14 economic traits at the Regional Poultry Breeding Laboratory, Lafayette, Indiana. Several breeding systems appear to have produced changes in the selected trait, percent hen-day egg production to January 1. In three generations, the system utilizing sire family selection with restricted inbreeding under study at the North Central Regional Poultry Breeding Laboratory has increased the selected trait by about 3%. Purposeful inbreeding within sire families selected on the basis of percent hen-day egg production to January 1 has decreased egg production by about 3.5%. An increase of 2.1% is apparent after two generations of selection in the system utilizing dam family selection. Three years of selection at Illinois based on individual records has produced little or no change in the selected trait. A randombred control population maintained at Minnesota by mass random mating of 250 breeder females showed no significant changes in egg production from the Regional Cornell randombred control. However, decreasing the number of females in the maintenance flock to 125 appears to have produced a small but consistent decrease in production over the three generations studied. This is suggestive of inbreeding depression due to small numbers of effective breeders. An unexpected increase in egg size of roughly 2 grams seems to have accompanied selection for percent hen-day egg production in the two sire family selection systems at Lafayette, the individual selection systems at Illinois, and the two systems on the maintenance of randombred controls at Minnesota. These systems were all started in 1958 and systems begun since that time have not shown this increase. For this reason, a correlated response in egg size is not necessarily indicated when selection is for hen-day egg production to January 1. An improvement in livability is indicated in many of the selection systems populations. Sexual maturity and egg quality traits have remained unchanged. (AH el-43)

Comparison of recurrent and closed-flock selection for growth rate at New Hampshire indicates a slight advantage in closed-flock selection for hatch of fertile eggs and shank pigmentation. Recurrent selection showed a slight advantage for 8-week body weight, March egg weight, 160-day body weight and March body weight. The work at this Station also suggests that after three generations of selection there was an increase in the closed-flock line and a decrease in the recurrent line in the relative contribution of nonadditive genetic to total variance in body weight. This research also provided evidence that the relative magnitude of nonadditive genetic to total variance in body weight was

greater at 4 than at 8 weeks of age. Indications of sex linked genes affecting yellow shank pigmentation intensity were noted. (AH el-45)

2. Randombred Control Populations.

Randombred populations are widely used as genetic and environmental controls and as a gene pool for use in initiating new research. Four such populations are maintained in the North Central region, two in the Southern region and one in the Northeastern region. (AH el-43, AH el-44, AH el-45)

Four years of data collected at the North Central Regional Poultry Breeding Laboratory on the Regional Cornell control population indicate that the annual egg production has increased from 58.4% in Generation 1 to 68.9% in Generation 4. In a similar period egg weight has decreased from 61.0 to 58.8 grams. Body weight has shown a similar tendency to decrease. With so little data it is difficult to interpret whether these are permanent genetic shifts, environmental time trends or random fluctuations. (AH el-43)

An analysis made by the North Central Regional Poultry Breeding Laboratory of the gene frequencies of ten simply inherited qualitative traits in the Regional Dominant Randombred population indicated no significant changes in these frequencies had occurred over the four generations studied. These results indicate that similarly maintained randombred controls are fulfilling the need of genetic stability, one of the requisites of a good genetic control. (AH el-43)

Most of the morphological traits in the Connecticut randombred population have remained fairly stable during the past seven generations. Exceptions include head spots, which have decreased from the F_3 to the F_6 generations. The percentages were 24.7, 16.3, 11.8 and 8.8, respectively, for these last four years. There has also been considerable variation in the amount of red plumage recorded for this population from the F_1 to F_6 generations. (AH el-45)

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Genetics and Interrelations of Performance Traits

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AREA NO. 9 - POULTRY - PHYSIOLOGY AND MANAGEMENT

Problem. Continuing basic research in avian physiology is essential to establish fundamental concepts and to increase the body of knowledge upon which ultimately must depend the resolution of many long standing issues of practical import, e.g., the "problems" of fertility, hatchability, growth and egg production. A continuing flow of basic physiological knowledge is necessary also for implementation of the subject matter of other disciplines. In some important areas, research to date has accomplished little beyond outlining the magnitude of the task at hand. In reproductive physiology, for example, the dominant role of the central nervous system is now generally recognized, but much intensive research will be required before we can expect any "useful" knowledge of mechanisms by which the varying actions of external and internal factors are integrated and directed to initiate, maintain or modify reproductive functions. Many aspects of environmental physiology, of responses to stress, and of growth and development likewise depend upon basic research for the bank of knowledge that can be applied toward useful ends. On the more immediately practical side, increased knowledge of poultry housing, related equipment and other management factors is necessary to provide optimal ranges of operational efficiency.

USDA PROGRAM

This is a continuing program, mainly on basic aspects of the physiology of avian reproduction, but including also applied studies pertaining to environmental physiology and management. In addition to physiologists, the work draws upon geneticists and animal husbandmen. Research is in progress at Beltsville, Maryland, and Glendale, Arizona, the work at Glendale contributing to regional project W-50. Cooperation currently is maintained with members of the Wistar Institute, Columbia University, the National Institutes of Health and the University of Pennsylvania.

Federal research in this area calls for 7.8 professional man-years, distributed to subareas as follows: Physiology of reproduction, 3.2; environmental physiology, 1.0; physiology of growth and development, 1.0; management practices, 1.1; and program leadership, 1.5.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State experiment stations in 1961 reported a total of 50.2 professional man-years divided among subheadings as follows: physiology of reproduction, 7.8; environmental physiology, 15.5; physiology of growth and development or other physiology, 13.2; and management practices, equipment and facilities, 12.7.

Reproductive efficiency and the physiological factors affecting fertility and hatchability are under investigation in chickens and turkeys. These studies involve an exploration of the nervous system and the endocrine system and their interrelationships in controlling the process of ovulation in the female and semen production in the male.

Atmospheric stresses on the reproductive performance of chickens is the subject being studied in W-50, where nine States and the USDA cooperate to determine the effects of different combinations of temperature, light and altitude. Basic research studies on stress are coordinated through NC-43, Physiologic Response of Laying Fowl to their Environment. Individual stations are working on light and heat as environmental variables, effects of environmental stress on production, the physiological response to a changed environment, and the effects of seasonal variation.

Hatchability investigations make use of techniques such as hereditary abnormalities, extreme temperatures during incubation, response of embryos to changes in gaseous environment, and X-irradiation. The physiology of the digestive system, the circulatory system and behavior also receive emphasis.

Chicken and turkey management research includes an evaluation of different flock replacement systems, work simplification studies, confinement and range rearing systems and cage and floor housing systems. Incubator management, equipment and space requirement in all phases of production and other factors related to production efficiency are also studied.

Industry and other organizations devoted approximately 50 professional man-years to the field of poultry physiology and management. Most of this work is directed toward new product development by pharmaceutical and feed manufacturers. Basic research is undertaken by only a few companies doing research in this area.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Physiology of Reproduction

1. Neuroendocrinology.

As was noted in last year's report, electrical stimulation with stainless steel electrodes of a region just above the median eminence of the hypothalamus appeared to result in delay of the hour of ovulation of the first follicles of the hen's sequences. Work completed during 1961 established strong grounds for believing that stimulation acts by delaying the release of ovulation-inducing hormone (OIH). While stimulation has been applied for a period of only ten minutes in all experiments, the delay in time of OIH release may be as great as 12 to 14

hours. Following upon the discovery by Everett and Radford that the effects of stimulation in the induction of ovulation in the rat are mediated by electrolytically deposited iron, it was shown that the delay of OIH release in the hen may be mediated similarly. The physical basis for long-continued stimulation (or "irritation") of nerve cells or fibres thus seems established, but the nervous and endocrine mechanisms by which the long-time effects are transmitted remain to be elucidated.

Further exploration of the hypothalamus has shown that delayed OIH release follows also upon stimulation of the preoptic region. Placement of electrodes systematically, from bird to bird throughout this area, has shown the effective loci to involve the ventromedian region of the preoptic hypothalamus extending from the median 3rd ventricle out to about 1mm bilaterally.

The fact that electrical stimulation of two regions in the hen's hypothalamus results in an apparent delay in OIH release, while stimulation of comparable regions in the brains of certain mammals causes premature discharge of this pituitary hormone, calls for a more thorough examination of the hen's central nervous system. As an initial step, hens were subjected to diffuse electrical stimulation of the head and spinal cord. These procedures, which are known to force premature ovulation in the mammal, were singularly ineffective in the hen and in many instances led to immediate and rapid regression of the ovarian complement of developing follicles.

In studying the neural control of ovulation in the hen, it is important to determine to what extent the secretion of gonadotrophins depends upon intact connections between the anterior pituitary and the hypothalamus. Trophic function of pituitary autografts to the kidney capsule of laying hens is accordingly under investigation. As adjudged by the rate of post operative regression of the ovary and oviduct, the pituitary transplant does not release detectable quantities of gonadotrophins. On the other hand, an apparently significant difference in the rate of comb regression between hypophysectomized hens and hypophysectomized hens bearing pituitary grafts may indicate that minute quantities of LH are elaborated and secreted into the blood stream. No evidence was found for prolactin secretion. Changes in adrenal and thyroid weights, relative to such changes in hypophysectomized birds, suggest a low level release of adrenotrophin and thyrotrophin. A much lower post operative mortality in hypophysectomized hens bearing transplants than in hypophysectomized birds without transplants is also indicative of some release of adrenotrophin or of thyrotrophin, or of both.

An attempt has been made to determine the approximate time of release of the ovulation-inducing hormone by assaying pituitaries obtained at

varying intervals prior to ovulation of the first or C_1 follicle for residual hormone. The assay unit, determined by preliminary trials, was that quantity of crude, air-dried pituitary powder which would force ovulation in 50 to 60% of 20 or more birds. Pituitaries were obtained from groups of 20 birds killed at intervals of 4, 10 and 14 hours prior to estimated time of ovulation of the C_1 follicle. Birds in a fourth group received an ovulatory dose of progesterone at 14 hours prior to ovulation of the C_1 follicle; the glands were removed 4 hours later, an interval sufficiently long to insure that OIH release had occurred. In a trial involving 126 birds, no appreciable differences were detected in the ovulatory levels of glands collected at any of the four intervals. (AH e3-15)

2. Parthenogenetic Reproduction.

The respective roles played by genetic factors and by live viruses in the initiation and organization of parthenogenetic development continues under investigation. During 1961, approximately 8,000 turkey eggs from virgin and nonmated daughters and granddaughters of an earlier parthenogenetic male were incubated. One hundred twenty-two parthenogenetic poults were hatched, a number almost twice that recorded for all previous years. Twenty-two of these parthenogenetic males matured, three of which have produced semen containing viable spermatozoa. Semen from these three males was used to inseminate virgin and nonmated (older) hens resulting in viable, normal appearing poults. A total of 10 parthenogenetic males have produced semen and 8 parthenogenetic males have sired offspring since 1952, when this project was started. Some of the 22 males produced in 1961 have been utilized in a cooperative study with members of the Columbia University Hospital, New York City.

During 1962, 8,519 eggs from virgin turkeys were examined. Of this number, 3,916 or 46% of the eggs showed some degree of development, the highest average level ever reached. A total of 1,071 embryos was encountered, including 94 poults which pipped and emerged, for the most part unaided, from the shells. Thus 27.3% of all eggs undergoing development gave rise to embryos while 8.8% of them actually succeeded in hatching.

The marked increases each year in the incidence of parthenogenetic development have been achieved largely as an outgrowth of a selective breeding program initiated in 1954. Sons of parthenogenetic males, or of parthenogens themselves when available, have been used as sires. Females likewise have been rigorously selected for their capacity to reproduce parthenogenetically.

Along with yearly increases in the incidence of parthenogenesis, there have also been significant changes in the proportion of organized to unorganized development. In 1952, only 1.3% of the eggs undergoing

parthenogenetic development gave rise to embryos. In 1962, 27.3% were so classified, representing a 21-fold increase over a 10-year period. Furthermore, the embryos which do develop are now surviving longer, on the average. In 1954 only 15.9% of all parthenogenetic embryos lived longer than 10 days, in contrast with 47.3% of all embryos still alive at 10 days of age during 1962.

The possible effects of live viruses in the induction and organization of this asexual type of development continues to be investigated. Additional data lend further support to the view that live fowl pox virus causes a significant increase in parthenogenesis in unfertilized turkey eggs. An increase in the incidence of the unorganized type of parthenogenetic development was also recorded following inoculation of turkey hens with live Rous sarcoma and Newcastle disease viruses. No increase was noted, however, when turkey hens of similar breeding were inoculated with killed fowl pox, Newcastle or Rous sarcoma viruses.

Significantly, the incidence of twinning among parthenogenetically developing embryos appears to increase following repeated use of live fowl pox virus. Monozygotic twins, triplets, etc., have been found in as high as 17% of eggs showing true embryo formation. Eight, three day old, parthenogenetic embryos was the greatest number found in a single yolk egg.

While certain live viruses have been shown to be associated with parthenogenetic development, it is also clear that the inheritance of an individual also plays a role. The exact contributions of each component have not been adequately demonstrated. To obtain more critical data on the relative roles of viruses and genetic factors, a cooperative experiment has been initiated with Pennsylvania State University. Since live fowl pox virus is not employed as a vaccine at Pennsylvania State it became feasible to study genetic factors both in the presence and in the absence of the virus. Fifty pedigreed, non-vaccinated turkey hens, furnished by the University, were segregated into two groups consisting of equal numbers of full sisters. One group of 25 hens was brought to Beltsville and there vaccinated for fowl pox. The other group of 25 birds was retained at the University as non-vaccinated controls. Unfertilized eggs from birds of both groups were incubated 10 days before being broken and examined in the usual manner. Nonvaccinated turkeys at Pennsylvania State University produced 734 unfertilized eggs, of which approximately 1% underwent parthenogenetic development. Vaccinated birds at Beltsville produced 1,262 eggs, with 5.55% of this number exhibiting parthenogenetic development. The experiment will be continued to ascertain the effectiveness of selection in increasing the incidence of parthenogenesis in vaccinated and non-vaccinated lines of common origin.

Information on the possible site and mode of action of viruses was obtained through the cooperation of Drs. Ray Bryan and Frank Rauscher

of the National Institutes of Health in a study to determine if virus, following inoculation of the hen, entered immature ova and could be recovered from eggs. A Black Minorca hen was inoculated intravenously with a potent strain of live Rous sarcoma virus. Fertilized eggs were obtained following insemination of this hen with semen from an unvaccinated Dark Cornish male. An extract, prepared from fourteen day embryos, was used as an inoculum and injected into 4-8 week old crossbred chickens which had been found free of antibodies to Rous sarcoma virus. Thirty days after inoculation, samples of blood were obtained and retested for presence of antibodies. The tests were repeated, using a second set of 4 crossbred chickens. Three of the 8 chickens developed fairly high antibody titers. No live virus could be recovered from newly laid eggs using conventional methods. The results suggest that virus, if present in eggs, is probably in the form of infectious DNA. (AH e3-19)

Two skin transplantation researches have been completed, using the chicken x turkey hybrid and the parthenogenetic turkey as experimental animals. The first, a cooperative effort with Drs. R. E. Billingham and W. K. Silvers of the Wistar Institute of Anatomy and Biology, involved reciprocal skin grafts between adult chicken x turkey hybrids and between these hybrids and unrelated members and the parental species. The results were unequivocal rejection of all grafts, regardless of donor, by the hybrids. Furthermore, hybrid whole blood inoculated to the chorio-allantoic membranes of chick embryos consistently produced embryonic splenomegaly. These findings clearly demonstrate the capability of the hybrids to recognize and react against foreign transplantation antigens. They are of particular interest in relation to the apparent lack of specificity of immunological tolerance of tissue grafts alleged to occur following chicken-turkey embryonic parabiosis.

The second, a cooperative project with Drs. Wm. V. Healey and Paul S. Russell of Columbia University, College of Physicians and Surgeons, involved reciprocal transplantation of wattle skin homografts between parthenogenetic Beltsville Small White turkey males and their dams, and a comparison of their survival times with similar grafts between normal nonparthenogenetic Beltsville Small White turkeys. Eleven grafts from parthenogenetic males to their dams have survived, some now more than 16 months, while the reciprocals were rejected in about two weeks. Similar grafts from normal turkey males to their dams survived approximately 21 days with subsequent complete rejection. Such grafts in randomly selected nonparthenogenetic turkeys were rejected in approximately 9 days with a second set reaction occurring at about the fourth day. These findings clearly demonstrate that there are no transplantation antigens present in the parthenogens which are not present in their dams, and prove that such birds are fully competent of reacting against "foreign" transplantation antigens present in their dams in a heterozygous condition. Further, they lend strong additional support to the contention that these eleven males are of parthenogenetic origin.

A further experiment is underway with the Columbia group to determine the responses elicited by reciprocal wattle skin homografts between parthenogens and their progeny by unrelated females. All homografts from progeny to parthenogens, and all except one homograft from the parthenogens to their progeny, have been rejected. The exceptional graft has not retained the appearance and texture of normal wattle skin, though there has been no clear evidence of a homograft reaction against it throughout the more than two months since it was transplanted. The rejection of the progeny of their parthenogenetic sire's skin is most significant in demonstrating that the parthenogen is heterozygous at one or more histocompatibility loci. Together with other observations, these results indicate that either nondisjunction at the second meiotic division or re-entry of the second polar body is the cytogenetic mechanism by which the diploid chromosome complement is established in the parthenogen. This work is presently being extended by regrafting a second set in the first group of birds, and by additional homograft exchanges between all available parthenogens and their progeny by unrelated females.

The survival time of reciprocal skin homografts between sibs and between dam and male progeny in the Beltsville Small White line selected for parthenogenesis is being used as a major selection criterion in an attempt to establish a line or lines of turkeys isogenic for transplantation antigens. Pairs which bear grafts of long time survival are being used as replacement flock matings and it is hoped that transplantation antigen isogenicity will be achieved in a few generations. Such selection techniques will also be applied in a colony of Japanese quail now being established in the Physiology Investigations Section. (AH e3-19 and e3-20).

An autosomal recessive mutation which in the homozygous condition produces nearly complete nakedness has arisen in Beltsville Small White turkeys. Symbol na has been proposed to designate this mutation. Crosses of heterozygous carriers produce a 3:1 ratio of normal to naked poults with no evidence for sex linkage or sex limitation. Progeny by artificial insemination of heterozygous females with a homozygous naked male's semen are in a 1:1 ratio of normal to naked. Only remigial feathers plus an occasional down feather are present on naked poults. The skin is otherwise devoid of feather follicles. Toenails and beak are normal but there are no scales on the shanks and feet. Gross anomalies of the hind limbs are common on either or both feet of most naked poults. Whether this polydactylism is the result of a separate but closely linked gene or a pleiotropic effect of the naked mutation is not known.

B. Environmental Physiology

1. Long-term Responses.

Work was continued, in collaboration with the Farm Electrification Branch of Agricultural Engineering on the reproductive responses of Beltsville Small White turkeys to environmental variables. Six pens of birds were maintained in a force-ventilated windowless house at $60^{\circ} \pm 5^{\circ}$ F., with some modulation of humidity; two pens received initially (Dec. 19, 1959 and Dec. 20, 1959), 11, two pens 13, and two pens 15 hours of artificial light daily. The performance of these "inside" turkeys was compared with that of six groups of "outside" birds maintained in conventional windowed houses with grassed yards; natural daylight was supplemented with artificial light each morning to provide initial photoperiods of 11, 13, or 15 hours in replicated pens. Photoperiods of both "inside" and "outside" birds were lengthened gradually with the later hour of sunset as the season progressed. No important differences were observed in egg production, fertility, hatchability and length of the breeding season in either "inside" or "outside" birds under 13- or 15-hour photoperiods. "Inside" turkeys under 11-hour photoperiods produced almost as many, 90 versus 97 eggs, as did birds under 13 or 15 hours of light, and compared favorably with hens under the longer photoperiods in all other respects. "Outside" turkeys under 11-hour photoperiods failed definitely to equal the egg production of "inside" birds under the same length of photoperiod (81 versus 90 eggs). The reason for this difference between "inside" and "outside" turkeys under similar photoperiods is not clear. When egg production records for "inside" and "outside" birds are combined for the 19-week breeding period ending May 31, turkeys under 11-, 13-, and 15-hour photoperiods produced an average of 83.0, 94.8, and 98.7 eggs, respectively, per hen. Except for some possible but unlikely influence on "inside" hens under 11-hour photoperiods, it appears that the temperature and humidity controls to which the "inside" birds were subjected in no way enhanced their reproductive performance.

It has been shown previously that out-of-season turkey hens (those hatched from eggs laid between September 1 and March 1) do not respond well in egg production to a further increased photoperiod. To elicit a favorable response, such hens must be subjected to a reduction in the amount or duration of the light received in the period immediately preceding egg production. A shortened light day, 6 to 9 hours, for a period of 3 weeks or longer has been shown in preliminary experiments, and by other investigators, to be effective in eliminating the failure to respond to increased photoperiods. In current tests, an 8-hour light period was compared with a "brownout" supplying below 0.1 foot-candle of incandescent white light during the hours of natural daylight between the ages of 20 and 30 weeks, after which the photoperiod was extended directly to 15 hours and increased gradually to 17 hours.

The "brownout" proved to be as effective as the 8-hour light day in preparing the hens for a successful breeding season. (AH e3-18)

Chickens hatched out of season have different patterns of egg production, and controlled photoperiods offer the possibility of achieving optimum performance. At Glendale, Arizona, three treatments included normal daylight to 20 weeks of age, 8 hours of light to 14 weeks of age then 16 hours to 20 weeks, and 16 hours to 14 weeks then 8 hours to 20 weeks of age. Differences over a 3-year period indicate that short 8-hour days to 8 weeks followed by 16-hour days to 20 weeks cause earlier sexual maturity and slightly lower annual production. There was little difference between normal daylight and the treatment involving 16 hours of light to 14 weeks followed by 8 hours to 20 weeks. It is possible that the latitude at Glendale does not cause as much seasonal variation due to hatch date as more northerly latitudes. Gradual changes in length of photoperiods may have a greater effect than the abrupt changes in photoperiods of this experiment and will be studied. (AH e3-16)

2. Environmental Chambers.

Work in this subarea is carried on in cooperation with the Livestock Engineering and Farm Structures Research Branch of the Agricultural Engineering Research Division.

Studies on the heat and moisture production of laying hens in cages and on litter were made and the results published. The heat and moisture dissipation data of these studies may be used for designing poultry houses. The common value of 5 to 6 BTU per hen per hour was found. The ratio of latent and sensible heat varied with the ambient temperature. On a weight basis S. C. White Leghorns produced the greatest amount of heat and N. H. x Cornish crosses the least. Turkeys of the Beltsville White breed were found to produce 4.7 to 5.8 BTU per pound per hour. The latent heat and sensible heat were about equal at temperatures 65° to 80° F.

General observations were made on the housing of broilers, weather conditions and the condemnation losses on processing inspection.

Further work is being planned on heat and moisture production of growing broilers and a strain of S. C. White Leghorns that may have heat tolerance in relation to egg production. Five environmental control chambers are being constructed to acclimatize the birds used in the calorimeter studies. (AH e3-13)

C. Physiology of Growth and Development

This work is an integral part of the research under (A) Physiology of Reproduction, (2) Parthenogenetic Reproduction, and is reported there in the interest of readability.

D. Management Practices

1. White Leghorn pullets, kept one bird to a 10" cage, 5 birds in a 24" cage and 8 birds in a 24" cage, indicate that multiple bird cages decrease egg production (from 134 to 123 to 115) and increase mortality (from 14% to 16% to 23%). Increases in mortality were evident in spite of debeaking to help control cannibalism. It is expected that more emphasis will be placed on the effect of environment on egg quality in future experiments. (AH e3-17)

2. Studies were undertaken to observe the practical value of dipping hatching eggs in an erythromycin solution as a means of reducing M. gallisepticum (PPLO), mortality, and condemnations.

Based on the results of two trials, it was observed that the dipping of eggs to control egg-transmitted Mycoplasma gallisepticum infection may depress hatchability under certain conditions which are not fully understood at present. There is an indication that the dipping of eggs may have produced chickens better able to survive cold room and hover conditions during the first two weeks of life. The dipping procedure was not always effective in either reducing mortality, condemnations, or the amount of M. gallisepticum (S₆ type PPLO) in the blood stream of broilers about 9 weeks of age. More work is needed to perfect methods of dipping eggs of practical value in commercial broiler production. (AH e7-1)

3. In a continuation of studies of the effect of light during the growing and laying periods on egg production, three different light treatments were used during the growing period: (A) 6 hours of light daily, (B) started with 22 hours and over the growing period decreased at weekly intervals to 6 hours, (C) normal daylight. The chickens on each growing treatment were divided into two groups when placed in the laying houses with each receiving a different light treatment. The results are as follows: Growing treatment A - 14 hours of light resulted in better performance than starting with 6 hours with weekly increases to 24 hours; Growing treatment B - starting with 6 hours with weekly increases to 22 hours gave better production than 14 hours; Growing treatment C - 14 (daylight plus artificial light) gave better results than starting with 6 hours of light with a weekly increase to 24 hours. (AH e2-14).

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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Physiology of Growth and Development

None (See Physiology of Reproduction)

Management Practices

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AREA NO. 10 - POULTRY - NUTRITION

Problem. The goal of nutrition research is to amass information so that poultry diets may be formulated and fed to produce the best quality product at the least possible cost. The problem logically divides into two areas: (1) furnishing the nutritive requirements of poultry, and (2) the feedstuffs that supply these requirements. A refined methodology is needed to estimate more accurately the energy (carbohydrates and fats), protein (amino acids), vitamin and mineral requirements of poultry of various ages, strains and level of production. But, even more urgently needed is information on the relationships that exist between these nutrients, if the formulation of optimum nutritive balance in diets is ever to be attained. Additional information is required on the effect of feed additives (antibiotics, arsenicals, hormones, enzymes, antioxidants, tranquilizers) on nutritive requirements, and on the utilization of protein and energy. Somewhere in the maze of requirements, interrelationships and interactions, it must be determined which portion of the diet is for intestinal microorganisms and which is for the host. Also, the vast field of interrelationships between disease and nutrition remains to be explored. In the feedstuffs area, how much of a particular nutrient that is present should be known, but of more importance is how much is available to the bird. Thus, information on digestibility, absorption, chelation and interactions is necessary. In addition, the complete composition of a feedstuff must be known. At the present, the proximate analysis is the only information available about major dietary constituents, consequently, the nutritionist does not know exactly what is being fed when a diet is formulated. There may be present growth promotants and/or inhibitors of which he is not aware. As a case in point, over 200 chemical compounds have been isolated from citrus fruit.

USDA PROGRAM

This is a continuing program conducted by nutritionists on basic and applied research on the nutritive requirements and digestion and metabolism of poultry and the nutritive value of feedstuffs. The work is in progress at Beltsville, Maryland, and at the Southwest Poultry Experiment Station, Glendale, Arizona. Some phases of work at Glendale are carried on in cooperation with the Departments of Biochemistry and Poultry Science of the University of Arizona at Tucson.

The Federal effort devoted to research in the poultry nutrition area totals 8.0 professional man-years. Of this number 3.7 are devoted to nutritive requirements, 2.0 to digestion and metabolism, 1.9 to the nutritive values of feedstuffs, and 0.4 to program leadership.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State experiment stations in 1961 reported 64.6 professional man-years divided among the subheadings as follows: nutritive requirements 32.8, digestion and metabolism 15.2, nutritive value of feeds 16.6. Some phases of research on poultry are being conducted at practically all of the State experiment stations; however, in a few States there is little or no work on nutrition. In contrast, there are many stations where nutrition research is predominant in the poultry program. Because of changes in diet formulation to obtain high-energy diets and the concurrent introduction of more refined and also new feedstuffs, the basic nutritive requirements of poultry are being re-evaluated. This work is concerned with sources of energy, amino acids, vitamins and minerals, particularly trace minerals. The interrelationships between nutrients are under investigation, along with the effects of disease level on nutritive requirements.

Studies are being conducted to determine more precisely the interrelationship of avian genetic constitution with the utilization of nutrients and the productive performance of poultry. The effect of feed additives on nitrogen metabolism, various body tissues, intestinal microflora, and physiological functions is being investigated with emphasis on the mode of action of these materials. Other basic research is concerned with the catabolism of amino acids in the liver and kidney, the utilization of yolk-sac calcium and phosphorus by the newly hatched chick and the absorption of minerals using radio techniques. Studies are being conducted on the nutritive properties of imported and locally grown feedstuffs in order to formulate the most economical and adequate rations. The biological value of different forms of feed (mash, pellets, crumbles, mash and grain combinations) is under investigation. Also, green feeds as a source of vitamins, and the improvement in feeding values of cereal grains by water and enzyme treatment are being studied. There is some work in progress concerned with the growth inhibiting principles in feedstuffs.

Industry and other organizations orient their research efforts primarily toward product development. This is particularly true with feed manufacturing companies where nutrition is practically entirely of an applied nature. Some pharmaceutical companies which supply the feed industry with various ingredients are conducting some basic research, but this is usually in connection with their products, and is seldom published. It has been estimated that this activity amounts to about 80 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Nutritive Requirements

1. Fat Requirements.

A highly significant increase in chick growth rate was obtained when fat calories were substituted for carbohydrate calories on an isocaloric and isonitrogenous basis. This was true for equalized nutrient intake as well as for ad libitum feeding. If growth response to egg oil is due to the presence of a growth promotant, the results of this work indicate that lard, corn oil, soybean oil and coconut oil also contain a common growth stimulant. Animal fat was as effective as vegetable oils in growth stimulation. The relatively more saturated lard, coconut oil and egg oil were just as effective as the less saturated corn and soybean oil.

When additional studies indicated that unsaturated fatty acids or a growth promotant might be involved in the growth stimulation attempts were made to inactivate the growth promoting ability of oil by heat, oxidation or hydrogenation in order to elucidate their role in growth. None of the treatments except hydrogenation has any effect on growth. The hydrogenated oil gave no response. (AH e2-13)

2. Protein and Amino Acid Requirements.

In a series of experiments to study the interrelationship of energy and sulfur-amino acids in growing turkeys, methionine was added to different basal diets to provide a range from 1.93 to 3.85 grams per therm of metabolizable energy. No significant interaction between basal diets and supplemental level was found, thus, indicating that the different basal diets had no effect on response. There was a significant response to sulfur-amino acid supplementation. The data indicates that amino acid requirement can best be expressed as a function of energy.

Studies on the protein requirements of pullets during the growing period indicated that a 21% protein diet from hatch to 8 weeks followed by 16% throughout the growing period, or 16% to 8 weeks followed by 12% to housing time supported better growth than did 16% throughout the growing period, or 16% to 8 weeks followed by 12% to housing time. In the first study conducted in floor pens, the results showed that on a 12% protein laying diet, the egg production was higher among pullets grown on 21% followed by the 16% protein diet than on the other two growing treatments. The second test which was conducted in laying cages did not confirm this result. In this study the grower diets had no effect on egg production, egg weights, feed conversion, or body weight gains irrespective of hen diet. The 14, 16, and 18% protein

levels in the hen diet showed no differences in egg production, egg weight or feed conversion. However, the 12% protein level resulted in lower production, smaller eggs and poorer feed conversion. (AH e2-16)

3. Mineral Requirements.

In work with trace minerals the individual addition of copper, molybdenum, potassium, zinc, and iodine to a practical type corn-soy diet used as a biological assay diet failed to elicit a growth response. In contrast, the addition of a commercially prepared trace mineral mix produced a highly significant response in the majority of the trials in which it was tested.

An 8-week test was conducted to study the effect of calcium and phosphorus levels on growth rate and bone calcification of two commercial broiler strains. The test involved two energy levels and calcium levels of 0.9, 1.0, 1.1, and 1.2% and total phosphorus levels of 0.5, 0.6, 0.7, 0.8, and 0.9%. The significant effects were strain, sex, energy, and phosphorus levels. The best growth was obtained at the 0.7% phosphorus level. The calcium levels used were not in the critical range and the responses were due entirely to phosphorus levels. The calcium and phosphorus levels used had little or no effect on bone ash or the calcium content of the bone ash.

Based on the information obtained in the first test, a second test was conducted with the calcium and phosphorus levels in a more critical range. In this trial the sexes were separated and calcium levels of 0.5, 0.6, 0.7, and 0.8%, and total phosphorus levels of 0.5, 0.55, 0.6, 0.65, and 0.7% were used. The significant responses were, calcium, phosphorus, sex and calcium x sex. The best growth was obtained with calcium levels of 0.7 and 0.8% with phosphorus levels of 0.55, 0.6, and 0.65%. From 0-6 weeks, feed conversion was influenced by calcium and phosphorus levels and sex. This effect was partially lost during the last two weeks, since 0-8 week data show responses only with phosphorus and sex at a lower level of significance. Bone ash at 8 weeks was significantly influenced by calcium and phosphorus and the ash of bones from females was significantly higher than that of the males. (AH e2-18)

B. Digestion and Metabolism

1. Metabolism of Fats.

In studies on the effect of type of dietary fat on plasma and liver cholesterol concentration in female chicks, it was found that the addition of 3% fat or oil to the diet without cholesterol supplementation did not increase plasma or liver cholesterol concentration. When 0.5% cholesterol was added to the diet, the type of oil had a definite effect. Chicks fed lard or vegetable oils had significantly

higher plasma cholesterol levels than did any of the chicks fed fish oils. Redfish oil was more effective than other fish oils in lowering liver cholesterol concentration. Addition of vanadium to the diet did not give reduction in cholesterol concentration in plasma or liver.

The effect of feeding egg yolk on the serum and yolk cholesterol content of hens was investigated. A diet containing 5% yolk, which furnished 1.6 grams of cholesterol per kilogram of diet, was fed to hens for about 4 years. At the end of this time there were no apparent differences between the cholesterol content of yolk and serum of the hens that received the egg yolk and those that had been fed the same diet without the yolk.

Results of studies on the effect of dietary fat on tissue fat and plasma cholesterol levels in broilers showed that the addition of corn oil and lard increased the fat content of breast and thigh muscle. Lard or corn oil did not increase the plasma cholesterol level. However, both plasma and liver cholesterol levels were increased when 12% yolk was included in the diet.

Laying hens fed a low-fat diet (0.36% fat by acid hydrolysis procedure) maintained body weight, but egg production and egg weight decreased. The oleic acid content of plasma and egg yolk increased, whereas the linoleic acid content decreased. At the end of the experimental period, the fatty acid content of the heart, liver, spleen, breast muscle, thigh muscle, abdominal fat and skin was determined. In contrast to the plasma and yolk it was found that some of the tissues of the fat depleted hens contained as much linoleic acid as those of the controls, and in some instances the arachidonic acid levels were higher. These results indicate that long-feeding periods of diets very low in fat will be required to determine if certain fatty acids are essential in the diet of the chicken.

Since it is known that the fat in the skin of turkeys becomes rancid much quicker than that in chickens, experiments were conducted to determine the fatty acid composition in the skin of these two classes of poultry. This was done by analyzing the extracted fat by gas liquid chromatography. The major difference in fatty acid content between the turkey and chicken was observed in the eighteen carbon polyunsaturated acids. The former contained approximately 60% more linoleic acid and 50% more linolenic acid than did the latter. Only trace amounts of arachidonic acid were found in the skin fat of either species. (AH e2-13)

2. Effect of Additives on Feed Utilization.

Studies conducted at Glendale to determine the effect of antibiotics and other additives on egg production in high ambient temperatures showed that furazolidone, bacitracin, oleandomycin, erythromycin

thiocynate, atteramin, and a combination of penicillin and streptomycin were of no benefit.

Further studies at Glendale, in cooperation with the University of Arizona, indicated that high levels of dietary antibiotics during hot weather had no appreciable effect on egg weight or shell quality.
(AH e2-15)

C. Nutritive Value of Feeds

1. Effect of Feeding Cottonseed Meal or its Constituents.

In studies at Glendale it was found that the "pink whites" in eggs caused by feeding cottonseed meal disappeared 4 days after cottonseed meal feeding was stopped. Further work with the cooperation of the University of Arizona in the cottonseed meal-gossypol area showed that discoloration in eggs from hens given crystalline gossypol was intensified when *sterculia foetida* oil was fed at the same time. This discoloration is probably due to the formation of a ferrous iron gossypol complex in the yolk at an alkaline pH. In additional studies with this oil, sterculyl alcohol was methylated and reduced to form the methoxyl and hydrocarbon derivatives. These two derivatives, sterculyl alcohol and polymers of sterculic acid and methyl sterculate, were fed to laying hens. The sterculic derivatives caused pink egg formations, but the polymers did not. Other studies have shown that neither the "available gossypol units" method, nor the ammonia test were accurate in predicting if yolks from layers fed cottonseed meal would be discolored after storage. It is postulated that a combination Halphen test and ammonia test would give reasonably accurate predictions.

Subsequent investigations at Glendale, in cooperation with the Southern Utilization Research and Development Division have indicated that pink whites in stored egg resulting from feeding cottonseed meal to laying hens is directly correlated with the Halphen positive constituent of the meal. This constituent induces an increase in the pH of the yolks during storage and the development of color is enhanced by the presence of the constituent, since the chromogen responsible for the brown color is pH sensitive.

Studies were conducted to determine the effect of combinations of antibiotics on the growth response of chicks fed fish solubles. The combinations were made up of antibiotics of broad and narrow spectrum effective against gram positive and gram negative organisms and an antifungal antibiotic active against yeasts. The antibiotic combinations failed to promote a more rapid growth rate and did not have any effect on feed efficiency. If the mode of action of antibiotics is concerned with intestinal flora, the materials used failed to remove effectively the complicating influence of intestinal bacteria.
(AH e2-17)

2. Nutritive Value of Grains.

Results of experiments on the nutritional significance of the proteins of corn and barley in laying diets indicated that a 10% protein diet containing corn was equivalent to a 14% protein diet containing barley in supporting egg production. In diets containing 10, 12, 14, and 16% protein when barley was replaced by corn, egg production was improved from 3 to 10%. (AH e2-16)

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AREA NO. 11 - POULTRY - IMPROVEMENT OF VIABILITY

Problem. Effective disease control is the number one problem facing the poultry industry today. One disease, lymphomatosis or avian leukosis, has ranked at the top for more than 30 years for its devastating effect on the health of chickens and the economics of their production. Basic information is needed regarding the biological and physical characteristics of the agent or agents causing visceral lymphomatosis and related neoplasms. Such information is a prerequisite of the formulation of sound research programs directed toward the development of control measures. There is need for a rapid and accurate method of bioassay to make possible many important studies on the biological expressions of the virus of visceral lymphomatosis and related neoplasms. Breeding studies involving induced lymphomatosis do not give clear genetic results. Genetic testing of inbred lines of chickens for the different disease entities involved in the avian leukosis complex will assist in clarifying the total problem. Nutrition, environment, and management undoubtedly influence the incidence of this disease. A coordinated attack on this major problem from every scientific standpoint is vitally essential.

USDA PROGRAM

This basic and applied research is conducted by pathologists, geneticists and animal husbandmen at the Regional Poultry Research Laboratory, East Lansing, Michigan. Some of the studies have as their objective the biological and physical characterization of the agent or agents causing visceral lymphomatosis and related neoplasms of the leukosis complex. Research is also underway on the pathogenesis of the three primary types of avian leukosis and other related neoplasms for the purpose of determining and evaluating their etiological, pathological, and immunological relationships. Efforts are also being made to develop a more rapid means of propagating in chickens the virus of visceral lymphomatosis than the orthodox method of producing it naturally or by inoculation.

Research on the pathogenesis of the three primary types of avian leukosis and other related neoplasms has included the collection of varying strains of the virus from flocks of chickens located in different sections of the United States. The responses when the viruses from the different sources are inoculated into chickens are being compared to ascertain their identity within the leukosis complex. This cooperative effort is supported financially by the American Cancer Society.

There are two phases of the genetics work related to avian lymphomatosis. One involves the development and maintenance of inbred lines

characteristically different in their resistance to lymphomatosis and related neoplastic diseases. One susceptible line is maintained in isolation to minimize infection with the disease. These lines provide relatively uniform experimental material for the study of nongenetic factors controlling disease expression and incidence. The second phase involves studies of the modes of inheritance of genetic differences in resistance to lymphomatosis and related neoplastic diseases. An objective of the second phase is to find efficient ways of identifying chickens genetically resistant to lymphomatosis as expressed by low mortality under field conditions.

An effort is being made to develop a vaccine that will be effective in the control of visceral lymphomatosis. Studies on the relation of cod liver oil in the diet to the incidence of avian leukosis are being conducted through a contract with the Wisconsin Agricultural Experiment Station, Madison, Wisconsin.

A cooperative project entitled, "Studies on the epizootiology of avian lymphomatosis and related neoplasms" calls for the active cooperation of (1) the Epizootiology Section, Epidemiology Branch, National Cancer Institute, (2) the Animal Disease Eradication Division, ARS, (3) the Regional Poultry Research Laboratory, ARS, and (4) the Poultry Industry Research Foundation. In addition, close liaison will be maintained with the State agricultural experiment stations where studies may be conducted.

The Federal scientific effort devoted to the research in this area totals 9.4 professional man-years. Of this number, 4.0 are devoted to studies of the causative agent of avian lymphomatosis; 1.0 to improvement through genetic methods; 2.7 to improvement through vaccination, feeding and management practices; and 1.4 to program leadership.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State experiment stations in 1961 reported a total of 4.5 professional man-years divided among subheadings as follows: improvement through genetic methods 3.1 and improvement through vaccination, feeding and management practices 1.4. An attempt is being made to identify biochemical differences in genetic systems between strains of chickens susceptible to disease, and those resistant to the same disease. Major emphasis is given to leukosis. Genetic correlations are being measured between biochemical genetic characteristics and subsequent performance. The practical value of results on such studies, together with research on stress factors as affecting physical expression of susceptibility or resistance, is being tested in breeding programs for the development of resistant stock. Some of this research is being conducted in cooperation with USDA.

The relationship of proper nutrition and management to the control of disease, primarily leukosis, is being determined. The effect of high temperature, poor ventilation, filth, and other stress factors on the incidence of disease also is being investigated.

Industry and other organizations devote about 10 professional man-years on avian tumor research. Most of this is on Rous sarcoma and is done in medical schools or medical research laboratories.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Studies of the Causative Agent of Avian Lymphomatosis

1. Characterization of Field Isolates of Leukosis Virus.

In extensive studies on the characteristics of new field isolates of leukosis virus, tumor, blood and other materials were obtained from 22 flocks located in various parts of the United States and having high mortality from lymphomatosis. Transmission was effected in line 151 chickens with cell-free inoculums of 19 of the 22 sources. The inoculum from one source was obtained from chickens with neural lymphomatosis, a second source from chickens with ocular lymphomatosis and a third source from a chicken with a nephroblastoma. All other inoculums were from chickens with visceral lymphomatosis and mostly from flocks with an early high incidence. The incidence of neoplasms induced varied considerably, although material from nine sources caused at least 50% mortality from neoplasms. In the experimentally infected chickens mostly visceral lymphomatosis was induced. Almost all inoculums also caused erythroblastosis. Other neoplasms induced were sarcomas, endotheliomas, nephroblastomas, osteopetrosis and neural lymphomatosis. Ocular lymphomatosis was not observed. Virus from eleven sources was studied in serial passage to characterize the oncogenic spectra and viral potency. For most of these virus strains at least four passages were made with both visceral lymphomatosis and erythroblastosis donor material.

Serial passages with visceral lymphomatosis tumor extracts have generally caused primarily visceral lymphomatosis; however, in a few passages many cases of erythroblastosis also occurred. Serial passages with extracts of livers from birds with erythroblastosis have generally caused erythroblastosis and in certain instances a high percent with sarcomas, endotheliomas, or osteopetrosis. Bioassays have shown that four passages with erythroblastosis cases have resulted in about a 10,000 fold increase in viral potency. None of the potent isolates have caused visceral lymphomatosis in line 151 chickens in less than about four months. Invariably when the virus titer was increased the birds died early of erythroblastosis. This increase in potency was accompanied by an increase in the number of different types of neoplasms

induced. A reduction in dose of virus inoculated causes primarily the induction of visceral lymphomatosis with a concomitant narrowing of the oncogenic spectrum. Further decrease in dose resulted in a decrease in the incidence of visceral lymphomatosis. Age of the chicken at the time of infection also markedly influenced the oncogenic spectrum. Generally, the younger the bird when infected, the more likely the occurrence of various types of tumors and accordingly embryos were found the most responsive. Intravenous inoculation of 11-day old embryos has resulted in a wide range of different neoplasms.

The avenue of exposure or route of inoculation and the genetic constitution of the host are other factors which have been found to markedly affect the oncogenic expression of a particular strain of virus.

The data obtained definitely points to a single virus that can cause erythroblastosis, visceral lymphomatosis, osteopetrosis, fibrosarcoma, endotheliomas and nephromas and that the several field virus isolates and strains recently studied are essentially similar. There was noted minor, yet notable and continuous differences in the pathologic characteristics between the several viral strains. Such differences may not reflect variations in antigenic constitution and thus are only of minor importance; however, they have been found to be quite stable in serial passage suggesting that they have a genetic basis.

The 11-day old chicken embryos when inoculated intravenously with a leukosis virus develop and hatch normally; however, neoplasia soon develops and death occurs in a much shorter time than if infection was delayed until after hatching. This procedure has been found to be particularly advantageous when many virus samples are assayed, such as for neutralization tests because they can be done in a much shorter time with a saving in cost and in pen space. It is also particularly useful in studies of the oncogenic spectrum because the embryo is much more sensitive than the chick in the development of various types of tumors. Another outstanding feature of embryo inoculation at 11 days is the fact that one avoids the effect of any maternal antibodies in the egg. Such antibodies are not transferred to the embryo from the yolk sac until about the thirteenth day of incubation. Thus inoculation on the eleventh day results in an infection without the effects of antibody. This is particularly important in measuring the genetic resistance of chickens without influence of other factors. Certain commercial crosses have been found to be quite susceptible to strain RPL 12 virus when inoculated as 11-day embryos but resistant when inoculated as day-old chicks. Other crosses were resistant when infected as embryos as well as chicks. The difference in the former crosses may have been due to antibody which is unrelated to innate resistance. (AH e6-10)

2. Serological Tests.

The in vitro neutralization test has been the primary procedure used in studies on the antigenic relationship between various viral strains and isolates. Measurement of unneutralized virus has been done by three different assay methods, i.e., inoculation of chickens, inoculation of embryos and the tissue culture RIF test. Most of the studies have been made with the leukosis strains RPL 12, 26 and 29, and with the Rous sarcoma virus (Bryan strain). Hyper-immune serums have been prepared in chickens. These serums, as well as serums from chickens in the field that have suffered natural outbreaks, were studied. It was found that most serums from natural infections that neutralize strain RPL 12 or other leukosis viruses also neutralize the Rous sarcoma virus. The discrepancy appears to be less than 10%. Thus the more simple and rapid Rous virus neutralization test can be used with confidence in field surveys on the occurrence of leukosis antibodies. This is a confirmation of findings by others.

Considerable antigenic variations among the several sources of leukosis virus were detected. Some of the newly isolated field viruses appear to be antigenically more diverse than strain RPL 12 and the Rous sarcoma virus. Viruses with similar oncogenic spectra may not have the same antigenic structure. The data strongly indicate that the antigenic variation of viruses causing different outbreaks in the field is sufficiently great to be of importance in the development of vaccines and the selection of antigens for serological tests.

The lack of a simple rapid serological test useful for the detection of antigen or antibodies of the leukosis viruses has been the largest obstacle in the development of control measures for this disease. Recently notable advances have been made in this area. The complement fixation test has now been modified to the extent that it can be used to detect and measure the Rous sarcoma virus antibodies. The sensitivity of the test is somewhat less than the neutralization test but detection and assay correlation of serums were very good. Lymphomatosis antibodies in turkeys of a flock with a high natural occurrence of the disease were detected by using the Rous sarcoma virus as antigen in the complement fixation test. These and other studies in progress point to a successful development of reagents and procedures for the complement fixation test which can be successfully used with chicken serums for the detection and assay of leukosis antibodies. (AH e6-17)

During the past year the indirect tissue culture method of detecting and assaying lymphomatosis virus has been tested further. This method depends upon the activity of a resistance inducing factor (RIF) to inhibit the formation of micro tumor foci in chicken embryo fibroblast cultures. By this method a virus preparation of strain RPL 12 has been assayed and found to have a titer of $10^{8.3}$ RI units per ml. This

agrees very well with the titer obtained by chicken inoculations. Preparations of other virus strains, and field isolates have been similarly assayed and related to chicken inoculation assays. The titer of lymphomatosis antibodies in sera from several sources have been determined by the RIF method and by the usual chicken inoculation procedure. In almost all of these determinations there was good agreement in the titers obtained by the two methods. These results have provided good evidence that the tissue culture method based on RIF activity is a valid one for the detection and assay of the virus(es) causing visceral lymphomatosis. (AH e6-24, pending)

B. Improvement through genetic methods

Further studies confirm that a large proportion of the genetic variability in response to inoculation with Rous sarcoma virus is controlled by a single recessive gene for resistance. Preliminary studies indicate that the relationship between genetic resistance to induced erythroblastosis and induced lymphomatosis is not a simple one. Artificial exposure does not produce a consistent increase in incidence of lymphomatosis in some lines of chickens. (AH e6-2)

Methods have been developed for studying genetic variability within the inbred lines using skin grafting and related techniques. Preliminary results indicate that some of the lines are relatively uniform for genes controlling major histocompatibility differences. (AH e6-28)

C. Improvement Through Vaccination, Feeding and Management Practices

Studies on the relationship of cod liver oil in the diet to the incidence of avian leukosis tend to implicate certain sources of the cod liver oil. Further work is necessary before definite conclusions can be drawn as to the importance of the relationship indicated. (AH e6-21(C))

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AREA NO. 12 - SHEEP AND GOATS - BREEDING

Problem. The existence of the sheep industry in this country will depend upon sheep producers being able to effectively and efficiently meet competition from other sources of meat and fiber. To meet this competition the farm sheep producer will need more efficient sheep, sheep which are capable of year-round production of more lambs and wool per ewe, often under adverse environmental conditions and with more resistance to disease and parasites. Range sheepmen need information on genetic methods of improving lamb and wool production. More effective systems of mating, breeding and selection need to be tested. Breeding studies on reproductive efficiency, as well as on the inheritance of feed efficiency, rate of gain and carcass quality deserve emphasis. Basic research on the inheritance of blood antigens is needed to implement other sheep genetic studies.

USDA PROGRAM

This is a continuing program by geneticists on basic and applied studies of breeding to increase efficiency of production of high quality lamb and wool. Work in progress at Beltsville, Maryland, involves breed comparisons and studies of gains resulting from crossing of breeds. At Dubois, Idaho, systems of mating are compared including development and crossing of inbred lines and selected strains. Also studies on heritability and other genetic parameters of economic traits, as well as studies on improved methods of selection are conducted. At Fort Wingate, New Mexico, and on a private ranch in Utah, selection studies are emphasized. Inheritance of blood antigens is being investigated in cooperation with the California Experiment Station. Cooperation is maintained with 15 other State experiment stations. Several of the studies contribute to the Western, Southern and North Central regional sheep breeding projects.

The Federal scientific effort devoted to research in this area totals 6.3 professional man-years. Of this number 1.5 are devoted to genetics and interrelation of performance traits, 3.1 to selection and systems of breeding, and 1.7 to program leadership.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State experiment stations in 1961 reported a total of 18.3 professional man-years, including 4.1 in genetics and interrelations of performance and 14.2 in selection and systems of breeding. Sheep breeding studies are coordinated through the W-61, S-29, and NC-50 regional projects. Eleven State stations and USDA are cooperating through the W-61 regional project in the development of selection criteria for the

genetic improvement of carcass merit of sheep. Initial efforts are concentrated on defining carcass merit through measures of the amount of lean in relation to fat and bone and in studies of eating quality. Seven States and USDA are cooperating through regional project NC-50 to determine heritabilities and interrelations of productive traits to facilitate improvement of lamb production through breeding. In the Southern region 10 States and USDA are cooperating through regional project S-29 to investigate genetic and physiological factors affecting reproduction of sheep. These regional and other State projects are producing information on genetic parameters of sheep, evaluation of breeds and strains, improvement of selection methods and performance testing and crossbreeding to increase efficiency of production and to develop improved strains of sheep.

Industry and other organizations conduct very little research in sheep breeding. An example of direct participation in research is the cooperative effort of the Redd Ranches with the Utah and Colorado State stations and USDA in applied research on improvement of range sheep through breeding. Similar improvement efforts are being carried out with other privately owned flocks. Breed associations and other organizations are cooperating in a number of performance testing and selection programs. The actual research effort provided by industry and other sources in sheep breeding is probably not more than 2.0 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Genetics and Interrelations of Performance Traits

1. Effects of Genetic and Environmental Factors.

At Dubois, Idaho, genetic and environmental effects on eight weanling traits of 3,227 Rambouillet, Targhee, and Columbia lambs reared during the topcross testing period 1955 through 1961 at Bozeman, Montana, have been estimated. Age of dam, type of birth and rearing, and age at weaning each had significant effects for nearly all seven years on weaning weight, body type, condition (fatness) and staple length at weaning in all breeds. Sex differences (differences between ewe and wether lambs) were significant, in general, only for weaning weight, face cover, and staple length. The sex differences seem to be more important in the Rambouillets than in either of the other two breeds. The type of winter feeding of the dam had no significant effect upon the weanling traits of the offspring. Face cover seemed to be affected significantly only by sex differences. Effects on side grade and crimp of wool at weaning were almost nonexistent, and neck folds were affected only to a small extent by sex and type of birth and rearing. Effects on staple length seemed to be somewhat more pronounced in the Rambouillets than in either the Targhees or

Columbias, although this may be simply a function of greater accuracy of measurement of staple length in the Rambouillets.

A study of the genetic and environmental effects on 26 fleece and body traits and the phenotypic correlations among these traits for 3,550 yearling ewes of Columbia, Rambouillet, and Targhee breeds for the years 1955 through 1958 has been completed. For the traits used in the yearling indexes, namely, body weight, staple length, body type, condition, fleece weights, face cover, neck folds and fiber diameter, differences caused by years were the largest. Other effects which were important for nearly all these traits were inbreeding, type of birth and rearing, and to a lesser extent, age from birth to shearing. Age of dam effects were important for body weight, staple length, fleece weight and for body type. Inbreeding of the dam and band in which herded were not especially important. The genetic differences among sheep (independent of inbreeding effects) caused by the several mating systems in use were sufficiently large to be highly significant for all traits in the Rambouillet breed, were of less importance in the Targhees, and relatively unimportant in the Columbia breed.

It was observed that the absolute magnitudes of the effects at yearling age caused by differences in maternal environment and days of age were (for those traits most affected by environment--body weight, type, and condition) generally only 30 to 60% of those at weaning age. However, the effects of the animal's own inbreeding at yearling age commonly ranged from 110 to 180% of those at weaning age illustrating the proportionately greater reliance of the animal upon itself as it matures. (AH b1-6, b1-14)

2. Correlations Among Traits.

All possible phenotypic correlations, independent of measurable environmental and genetic effects were calculated for 26 fleece and body traits of yearling ewes. The degrees of freedom were such that all correlations above .06 to .08 were significant. The correlations among fleece traits tended to be higher (.10 to .20 higher) for the coarser and more variable Columbia and Targhee breeds than for the Rambouillet. The only notable correlations between fleece and body traits were those involving body weight and circumference of chest and grease and clean fleece weight. All others were low, most being nonsignificant. The correlations among body traits generally were moderately high (.40 to .70) for those traits which describe torso dimensions, such as body type, body width, or body depth. Circumference of chest and body type were the traits most highly correlated with body weight, .67 and .57, respectively. However, body weight generally had the highest correlation with all body traits. Except for circumference of chest, the measured traits appeared to be no more accurate in describing other body traits than scored traits yet are more time consuming to measure or observe. Circumference of the chest seems to be

the most useful of all measured traits and is one of the most easily measured.

In additional work on methods of estimating clean fleece weight, it was found that multiple regression equations involving grease fleece weight, staple length, body weight, fiber fineness, machine reading and crimps per inch produced multiple correlations with clean fleece weight ranging from .88 to .96. These were slightly higher than those obtained when using small side samples to predict clean fleece weight. It was also found that when grease fleece weight, machine reading, and staple length were used in the regression equations, the other traits contributed but very little to the accuracy of the prediction equation. The side sample method appears somewhat more accurate if only a single trait is to be used; however, its limited superiority seems insufficient to justify the disadvantages in time and expense requisite to its use. To further substantiate these findings the multiple regression equations subsequently were used to estimate whole clean fleece weights on data entirely independent of those from which the equations were derived. The data consisted of observations on 198 yearling and mature ewes and rams. Correlations between the estimated and actual clean weights ranged from .82 to .93 for fine, 1/2, 3/8, and 1/4 blood fleeces. Correlations between estimates obtained by scouring small side samples and the actual clean weights on the same fleeces ranged from .68 to .91. Comparable correlations involving grease weight and actual clean weight ranged from .70 to .89 and those involving squeeze machine reading and clean weight ranged from -.79 to -.91. These results corroborate earlier conclusions that estimating clean fleece weights from appropriate multiple regression equations is generally the most satisfactory means of obtaining these estimates. (AH bl-6)

3. Blood Serum Analysis.

Blood serum protein fractions were determined on 80 Targhee, Columbia, and Rambouillet ewes bled during 1960. The objective was to investigate the relationship between serum proteins and degree of inbreeding by lines. There appeared to be no important relationship between the average inbreeding and the average levels of serum protein fractions of the line. These data tend to confirm earlier findings, however, of consistent breed differences for serum protein fractions, Rambouillets having lower gamma globulin and higher albumen levels and higher albumen-globulin ratios than the Columbias, with the Targhees occupying an intermediate position. (AH bl-6)

4. Genetics of Feed Utilization.

Analyses on the 5 years of data obtained on the efficiency of gain of 226 individually fed Rambouillet ram and ewe lambs and a comparable lot of 218 group fed lambs have provided additional estimates of the effects of age of dam, type of birth and rearing, sex,

band and age of lambs on a large number of performance traits studied including efficiency of feed conversion and rate of gain on feed test. Heritability estimates of these traits in many instances varied between the two conditions under which the sheep were managed for the feed test, however, evidence of large sampling error due to limited numbers discounts the conclusion of different heritabilities under different conditions. Heritability estimates for certain traits were similar for the two conditions. (AH 11-13)

5. Investigation of Blood Group Relationships in Sheep.

Cooperative work with the University of California at Davis, concerned with blood groups in sheep and closely related species, has been continued. A rather unusual trizygotic set of Suffolk triplet lambs has been found. The female member of this set possessed red blood cells of two distinctly different serological types, one of which she shared in common with the two males and the other which was unique to herself. The ratio of the two kinds of red cells were originally 50:50, but by 10 months after this test the ratio was 95:5. This regression of one of two populations of chimeric blood cells has been reported in man but not in chimeric or mosaic twins and triplets in sheep. Although this ewe lamb would pass as a normal, potentially fertile female, the results of the blood-typing and skin-grafting experiments indicate that she was joined in a communal vascular system with the two ram lambs during prenatal life and therefore is probably a freemartin. In another case a so-called "hermaphrodite" female lamb born twin to a male was also found, by the use of blood typing techniques, to actually be a freemartin (a rare event in sheep).

Serum samples from 100 sheep were examined for their content of hemolysins for cattle red cells. Six of the samples contained antibodies for blood factor F_1 of cattle. Successful transformation of J-negative goat red cells to J-positive was accomplished by placing them in plasma from J-positive goats, much in the manner described for cattle red cell transformation.

Isoimmunizations were performed using 35 rams and 2 ewes as recipients. These immunizations were planned to stimulate antibodies for known blood factors in order to help replenish stock antisera and reagents. Antibodies for 5 blood factors were duplicated and in addition antibodies for a previously unrecognized factor were found. Six rabbits were used to replenish the supply of anti-Z reagent. A new antibody was encountered which acts as an agglutinin rather than a hemolysin.

Blood typing of approximately 900 ewes and their mates in 1961 from inbred Rambouillet lines and the selected control group of the Rambouillet, Targhee, and Columbia breeds at Dubois, Idaho, has been done at Davis, California. Blood samples will be collected on the

1962 weanling offspring. Studies will be made regarding calculated levels of heterozygosity of the blood group factors and of the association between blood groups and certain production traits. (AH bl-15)

B. Selection and Systems of Breeding

1. Breed Comparisons and Crossbreeding.

This work was undertaken to compare breeds in their ability to produce wool and lambs and their value in a crossbreeding program designed to study increased production due to hybridization. Initial comparisons involved the Hampshire, Shropshire and Southdown breeds. The total production of these sheep has been measured by an index which combines the pounds of lamb weaned with the pounds of wool produced divided by the fall body weight of the ewe. The average production index for the past 14 years is 70.0, 57.9, and 53.6 for the Hampshires, Shropshire, and Southdown breeds, respectively. (AH bl-1)

In the crossbreeding studies, the two-breed crosses include Shropshire, Southdown, and Merino rams mated to Hampshire ewes; and Hampshire, Southdown, and Merino rams mated to Shropshire ewes. The average production index of all two-breed crosses was 71.4. The comparable average of the purebred parents making up these crosses was 63.1. The average index for the crosses involving the Hampshire ewes was 92.3 compared to 54.7 for the Shropshire ewes. In 1961, the three-breed crosses involved the mating of Hampshire, Shropshire, Southdown, and Merino rams to two-breed cross ewes; and two-breed cross rams to purebred Hampshire, Shropshire, and Merino ewes. The average index for the crossbred ewes mated to purebred rams was 88.3 and for the purebred ewes mated to crossbred rams was 88.7. Thus, the three-breed crosses show increases of 39% over the comparable average index of 63.7 for pure breeds involved.

The total pounds of lamb weaned from a flock of sheep depends upon the weight of the individual lambs and the number of lambs weaned. The number of lambs weaned is dependent upon the fertility and prolificacy of the ewes and the livability of the lambs. To study the effect of crossbreeding on fertility, prolificacy and lamb livability of purebred vs. 2-, 3-, and 4-breed cross matings, data were analyzed which included a total of 2962 ewes bred, 2646 ewes lambing and 3428 lambs born alive for the years 1952-1959. Fertility was measured by the percent of ewes lambing of ewes bred. It was found that 88% of the purebred ewes lambed of ewes bred, 89% of the ewes lambed which produced 2-breed cross lambs, 90% of the ewes lambed which produced 3-breed cross lambs and 92% of the ewes lambed which produced 4-breed cross lambs. Prolificacy was measured by the percent of lambs born of ewes lambing. The percentages for ewe producing purebred lambs, 2-breed cross lambs, 3-breed cross lambs, and 4-breed cross lambs, were 134, 128, 148, and 149, respectively.

Lamb livability was measured by the percent of lambs born alive to total lambs born and lambs weaned of live lambs born. The percent of lambs born alive of total lambs born for purebred mating, ewes producing 2-, 3-, and 4-breed crosses was 93, 95, 95, and 97, respectively. For lambs weaned of live lambs born these percentages were 82, 84, 84, and 89. Since the percent of lambs weaned of ewes bred included fertility, prolificacy and lamb livability it is the best single measure of lamb productivity. The percentages for purebred, 2-cross, 3- and 4-breed crosses for this trait were 90, 92, 104, and 117, respectively.

Significant differences were found between years, age of dam, type of birth and breeds and crosses for fertility, prolificacy, and lamb livability except between years for livability at birth. Age of dam showed an important effect on prolificacy with an increase from 126 to 153 lambs born of 100 ewes lambing from 2-year-old ewes to those 9 years and older. Fertility and lamb livability tended to be lower for the young and old ewes than for those of the middle ages. The peak for percent lambs weaned of ewes bred was reached at 4 years of age. A higher percent of single lambs was born alive and a higher percent of single lambs born alive was weaned than of twins.

In purebred matings Hampshires, Merinos and Columbia-Southdale, excelled over Shropshires and Southdowns in percent of lambs weaned of ewes bred. Hampshires and Columbia-Southdales ranked highest in prolificacy, and Merinos ranked highest in fertility and lamb livability among the breeds studied.

Fertility, prolificacy, lamb livability and overall reproductive ability were generally higher for crossbred than for purebred matings. Furthermore, there was an upward trend with an increase in the number of breeds involved in the cross. Two-breed crosses tended to rank in somewhat the same order as the dam's breed and were not significantly greater than the purebred matings for any of the traits studied. Consistent effects of breeds or breed combinations were not readily apparent in reproductive traits of 3- and 4-breed crosses. Average increases in percent lambs weaned of ewes bred were 2.1, 14.9, and 27.1 for 2-, 3-, and 4-breed crosses, respectively, over the comparable averages of the purebred parents. (AH bl-2)

Merino ewes were mated to Hampshire, Shropshire and Southdown rams, and their production compared to Merino X Merino matings to study the probable increase in total production resulting from mating wool-type ewes to meat-type rams. In 1961, the average index for purebred Merino matings was 61.8, while Merino ewes mated to Hampshire, Shropshire, and Southdown rams gave average production indexes of 118.3, 115.8, and 83.8 for each cross, respectively. When Hampshire-Merino, Shropshire-Merino, and Southdown-Merino crossbred ewes were mated to meat breed rams an average index of 102.1 was obtained. (AH bl-4)

2. New Strains of Sheep for Lamb and Wool Production.

Work toward the development of the Columbia-Southdale strain of sheep is being continued at Beltsville, Maryland, and in cooperation with the Vermont Agricultural Experiment Station at Middlebury, Vermont. These sheep are being developed as a dual-purpose breed to produce a maximum of high quality $3/8$ and $1/4$ Blood wool and a desirable meat-type lamb under Eastern farm conditions. Data from Beltsville and Middlebury concerned with weanling and yearling traits of this strain were combined in an analysis which resulted in estimates of heritabilities, genetic and phenotypic correlations and a comparison of the Columbia vs. the Columbia-Southdale strain. Significant effects of year of birth, age of dam, type of birth and rearing, sex, breed and station were found. The traits most influenced by the measurable environmental factors were weaning weight, type and condition, and yearling body weight and fleece weight. The year of birth was the most consistent cause of environmental differences of any of the effects studied. Heritabilities of weaning weight, type and condition, and yearling body weight were found to be 0.14, 0.14, 0.15, and 0.13, respectively. Heritabilities for yearling type, condition, fleece weights, fleece characters and staple length were 0.32, 0.45, 0.67, 0.66, and 0.73, respectively. Of the 36 phenotypic correlations all were positive with the exception of four and only one of these, between yearling fleece weight and fleece character, was statistically significant. Negative genetic correlations were found between yearling body weight and weanling type; yearling fleece character and staple length; yearling fleece weight and yearling condition, type and fleece character. Staple length was negatively correlated with yearling condition and fleece character. However, the majority of all traits were positively correlated and weaning weight showed a positive relationship with every other trait. In the comparison between the Columbia and the Columbia X Southdale it was found that the Columbia sheep were heavier in weaning weight, yearling weight, had heavier fleeces and greater yearling staple length. The Columbia X Southdale sheep ranked higher in weaning type, condition, yearling type, condition and fleece character scores than the Columbia. (AH bl-3)

Seasonal restrictions of reproduction in sheep results in uneven supplies of slaughter lambs throughout the year. In many areas it is advantageous to produce lambs in the fall of the year, a time when present domestic breeds do not reproduce in abundance. More intensive and more efficient lamb production, especially in farm flocks, would be greatly facilitated by strains of sheep which would efficiently reproduce every 6 to 8 months and do this without seasonal restrictions. The development of such a strain of sheep will demonstrate the effectiveness of selection to change reproductive frequency and to remove seasonal restrictions on reproduction. Thus, work has been started on the development of a strain of sheep capable of reproducing more than

once per year. Matings are made in April, December, and August to produce three lamb crops in two years. Lambs are weaned at 60 days of age. Of 122 ewes bred in April-May of 1961, 61 lambed producing 71 lambs. A total of 21 of these lambs were born dead and 35 were weaned. Ewes lambing in September were rebred in December. Of 90 ewes bred, 40 lambed, producing a total of 50 lambs of which 42 were weaned. (AH bl-17)

3. Comparisons Among Systems of Breeding.

The investigation of systems of breeding for improvement of range sheep has continued at Dubois, Idaho, with comparisons being made among systems involving inbred line formation, line crossing, top-crossing inbred sires on unrelated ewes, mass selection without inbreeding (selected control), random mating without inbreeding (stabilized control), and recurrent selection of sires for superior general combining ability. The comparisons are based on the merit of unselected weanling offspring produced by each system for the Rambouillet, Targhee, and Columbia breeds over the four years 1958-61.

In general, the systems involving top-crossing of inbred sires and mass selection without inbreeding (selected control) continue to produce offspring of superior overall merit. Within the Rambouillets, the top-cross offspring remain superior in weaning weight; but the selected control offspring are superior in overall merit, chiefly because of more open faces, less wrinkled necks, and longer staple lengths. The two systems are very nearly equal in the Targhees, while the top-crosses have a slight superiority in overall merit in the Columbias. Weaning weights for the two systems are almost identical in the Columbias.

The line cross offspring continue, in general, to occupy an intermediate position (along with the recurrent selection test offspring) although their position in the Targhees, where they have ranked first in overall merit and weaning weight for the past two years (1960 and 1961), is relatively more favorable than in either of the other two breeds.

Offspring from the stabilized control and the inbred lines are inferior to those from all other systems. The stabilized control offspring generally are superior in weaning weight but slightly inferior in overall merit (chiefly because of slightly more covered faces and wrinkled necks in the Rambouillets and Targhees and shorter staple length in the Columbias) to the inbred line offspring. Only two years of data are available on Targhee and Columbia stabilized control offspring, which makes their positions relatively more tentative than that of the Rambouillet stabilized control. (AH bl-5)

4. Testing of Inbred Lines.

The testing of inbred lines by top-crossing inbred sires upon noninbred test ewes has continued at Dubois, Idaho, and Bozeman, Montana. At Dubois, 57 sires representing all 27 inbred lines of Rambouillets, 20 inbred lines of Targhees, and 10 inbred lines of Columbias were tested on three to seven noninbred test ewes per sire. Final results also are available on 82 Rambouillet sires from 19 Rambouillet inbred lines, 40 Targhee sires from 8 Targhee lines, and 42 Columbia sires from 9 Columbia lines tested at Montana during the period 1955 through 1961. In addition, results are available on 14 Rambouillet, 7 Targhee, and 7 Columbia purchased sires along with an equal number of noninbred (selected control) sires tested during the same period. Results are based on the average merit of unselected weanling offspring.

Three-year averages (1959-61) of test results at Dubois reveal that 9 of the 27 Rambouillet inbred lines had top-cross offspring superior to those of the best selected control pen in overall merit (index), and 20 of the inbred lines were superior to the best selected control pen in weaning weight. Twenty of the inbred lines had top-cross offspring exceeding those of the purchased rams in both overall merit and weaning weight. Six of the 20 Targhee lines tested had 3-year averages for overall merit superior to that of the best selected control pen, and 7 had averages for weaning weight superior to that of the best selected control pen. Thirteen of the 20 lines had averages for overall merit and 7 had averages for weaning weight better than those of the purchased rams. Eight of the 10 Columbia inbred lines had 3-year averages for overall merit and 5 had averages for weaning weight superior to those of the best selected control pen. However, only 2 of the lines had test progeny averages (for both overall merit and weaning weight) superior to those of the purchased Columbias.

Because the lines tested at Montana could not all be tested simultaneously in any year, it was difficult to make accurate individual comparisons among all the lines. However, comparisons of the 7-year averages over all inbred lines, all purchased rams, and all noninbred (selected control) rams within each breed reveal that for overall merit in both the Rambouillets and Targhees the selected control progeny ranked first, the inbred line progeny second, and the purchased sire progeny last. In the Columbias, however, the purchased sires had superior progeny, the line sires ranked second, and the selected control sires were poorest. These rankings for overall merit were identical to those for comparable three-year averages of tests at Dubois for all breeds although they are based on averages which include only 9 of the 27 Dubois Rambouillet inbred lines, 5 of the 20 Targhee lines, and 6 of the 10 Columbia lines. For weaning weight, the respective rankings in the Columbias were identical to those for overall merit, both at Montana and Dubois. In the Rambouillets,

however, the selected control progeny were first at Montana and last at Dubois; the purchased sire progeny ranked second at both locations; and the progeny of inbred sires ranked last at Montana and first at Dubois. For the Targhees, the progeny of selected control sires were first in weaning weight at Montana and last at Dubois, the purchased sire progeny had exactly the opposite ranking at each location, and the progeny of inbred sires were second at each location. The above differences in Rambouillet and Targhee test results at the two locations probably can be attributed partly to sampling variation associated with differences in the kind and number of test animals used and partly to the fact that only a small porportion of the lines tested at Dubois were also tested at Montana. This testing will be continued until more decisive results can be obtained, particularly for individual line comparisons. (AH b1-14)

5. Selection for Range Sheep Improvement.

Increased lamb and wool production through use of high quality rams has been clearly demonstrated over four generations of selective breeding at Fort Wingate, New Mexico. The project was initiated in 1952 with ewes obtained from the Navajo Reservation with average clean fleece weights of 2.0 pounds and staple lengths of 2.1 inches. Three random groups of these ewes were bred each year to highly selected rams of the Targhee and Rambouillet breeds and of the weaving wool strain from Fort Wingate, respectively. The fourth group was bred to rams of the same breeding as the original ewes and selected at random each year. Second generation ewes sired by the weaving wool rams produced clean fleece weights about 50% heavier than the control or representative Reservation ewes. Marked increases over the controls of 36 and 23%, respectively, were found for the Targhee and Rambouillet sires. Similar differences were found for staple length with increases of 71, 29, and 33%, respectively, for the 3 breeds of sires. Average weaning weights of lambs at 120 days were also much higher for the improved sires with an increasing advantage through the first four generations. Targhee sires showed the greatest advantage of 26% followed by 25% for weaving wool sires, and 15% for Rambouillet sires over the average reservation lambs born under the same conditions in the same year.

Weaning weights as affected by pasture differences were studied at Fort Wingate during the years 1958 to 1961. During 1960-61 the ewes with their lambs were herded on a new range about 6 miles west of the range used in 1958-59. The new range had better watering facilities in terms of number and distribution or location of the tanks. There were fewer trees on the new range and also a greater variety of range plants. Precipitation during each of the four years was 10.78, 11.72, 8.03, and 10.14 inches, respectively, for 1958, 59, 60, and 61. Average weaning weights of lambs on the new pasture were 12.4 pounds greater for the ram lambs and 11.1 pounds greater for the ewe lambs than for the old pastures. These figures include lambs from all eight

breeding groups maintained at the Fort Wingate station. Rather large differences in weaning weights of lambs between breeding groups were noted between the 1958-59 season and the 1960-61 season. On the poor range, advantage in weaning weights of the two improved strains and the Targhee line over the old type Navajo ram lambs was about 2 pounds. But during the relatively good year of 1960-61 on the better range this advantage in weight of the improved strains over the old type Navajo lambs was about 10 pounds in the weaving wool and Targhee lambs and 8 pounds for the fine wool strain. For the ewe lambs these differences were 3 pounds advantage on the poor range and 10 pounds advantage on the good range. This same trend was also noted between the improved strains in the demonstrational groups where Targhee rams, weaving wool rams and Rambouillet rams are being used to demonstrate the grading up of the average reservation sheep through breeding and selection. These weight differences, no doubt, illustrate that the advantages of improved strains are greater under good feed conditions. (AH bl-10, bl-11, bl-12)

Research on the rate of improvement in wool and lamb production resulting from a practical breeding and selection program under range conditions is being investigated at the Redd Ranches, La Sal, Utah, in cooperation with the Utah and Colorado State Experiment Stations. In 1961, 201 ram lambs were saved of 501 ram lambs weaned. The selected lambs averaged 92 pounds in body weight, their fleeces averaged 1.80 inches in staple length, and face cover was scored at 3.01, showing advantages over all lambs weaned of 11 pounds, 0.14 inches and 0.2 score, respectively. Of the ram lambs that were saved, 74.6% were polled, 18.4% were horned, and 7.0% had scurs as compared with 67.9, 24.4, and 7.7, respectively, for all lambs weaned. (AH bl-16)

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AREA NO. 13 - SHEEP AND GOATS - PHYSIOLOGY

Problem. Inefficient growth and reproductive failures are costly to sheep producers and cause large reductions in efficiency of production. Additional information is needed on the causes of reproductive failures in the female and low fertility or sterility in the male. Also, more information is needed regarding the basic physiological processes involved in growth and reproduction. The normal physiology of all phases of growth and reproduction must be more thoroughly defined along with the effects of important genetic and environmental factors such as breed, age, season and level of nutrition in order to develop more effective ways of increasing efficiency. Basic information is also needed concerning the development and growth of fiber follicles in order that further improved practices can be developed for wool and mohair production. This research requires studies on the nature and sequence of histological, cytological, and physiological processes involved in fiber follicle initiation and development.

USDA PROGRAM

This is a continuing program conducted by physiologists and histologists on basic and applied studies of the physiology of reproduction, growth, and development of sheep and goats, including processes involved in fiber follicle initiation and development. Factors influencing mating behavior, estrus, ovulation, and embryonic development in ewes and mating behavior and fertility of rams are directed toward a more complete understanding of the reproductive processes in sheep. The work is in progress at Beltsville, Maryland; Dubois, Idaho; and El Reno, Oklahoma, and cooperatively with Idaho and Oklahoma State Agricultural Experiment Stations. Environmental factors affecting growth and development are being studied in cooperation with five State experiment stations. One study contributes to the Western regional project W-46 on the effects of environmental stresses on range cattle and sheep production. Studies on fiber and follicle development of sheep and goats are in progress at Beltsville, Maryland, in cooperation with the Texas Agricultural Experiment Station.

The Federal scientific effort devoted to research in this area totals 3.7 professional man-years. Of this number 1.7 are devoted to physiology of reproduction, 0.1 to environmental physiology, 1.5 to physiology of wool and fiber, and 0.4 to program leadership.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State experiment stations in 1961 reported a total of 8.0 professional man-years including 3.9 in physiology of reproduction, 2.3 in

environmental physiology, and 1.8 in the physiology of growth and development. This research is currently being conducted by stations in all four of the regions with research in two regions being coordinated through S-29 and W-46 regional projects. In the Southern regions, 10 States and USDA are cooperating through regional project S-29 to investigate physiological, as well as genetic, factors affecting reproduction in sheep. In the Western region 10 stations and USDA are cooperating through regional project W-46 to study effects of environmental stresses on physiological responses of range cattle and sheep.

Research at the State experiment stations in sheep physiology is concerned primarily with the endocrinology of seasonal breeding behavior and other aspects of reproduction and means of altering them. Environmental physiological studies are mainly concerned with stresses of nutrition and temperature. In work on growth and development the effects of hormones, hormone-like substances and the feeding of specific metabolites such as sodium proprionate are being studied.

Industry and other organizations conduct very little research in sheep and goat physiology. The effects of hormones and hormone-like substances alone or in combination with antibiotics on growth and physiological reaction of sheep are being studied by a few pharmaceutical manufacturing companies. Artificial breeding associations are conducting a little experimental work with artificial insemination of sheep and goats. It is estimated that research by industry and other organizations amounts to not more than 3.0 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Physiology of Reproduction

1. Flushing Studies with Range Sheep.

a. Effects of Feed and Length of Flushing Period on Lamb Production in Targhee and Columbia Range Ewes.

Oat supplementation (.7 lbs per head per day) in the years 1957 to 1959 had a significant effect in mature ewes on number of live lambs born, pounds of live lamb born, and pounds of lamb weaned at Dubois, Idaho. On the basis of ewes present at lambing time the best treatment increased number of live lambs born per ewe 0.24, the weight of live lambs born 2.5 pounds and weight of lambs weaned 18.6 pounds. A short flushing period (17 days) immediately prior to breeding increased lamb production over the controls. Extending this period an additional 17 days during breeding produced no further increase in production but increased costs. A further 17-day extension caused an apparent production decline from that obtained by shorter flushing periods.

Ewes on native grass hay fed in drylot for 17 days prior to breeding had lower lamb production than those maintained on dry, native pasture. Alfalfa pellets had an apparent but nonsignificant flushing effect on lamb production in mature ewes. Neither oats nor alfalfa pellets had significant flushing effects on two-year-old ewes.

Both oat and alfalfa pellet supplementation significantly increased body weight during treatment in mature and two-year-old ewes. Change in body weight during treatment was not significantly correlated with lamb production. (AH 61-7)

b. The Effect of Length of Supplemental Feeding Prior to Breeding on Lamb Production in Rambouillet Range Ewes.

Approximately 630 mature Rambouillet ewes were given no supplement (control) or were supplemented with 1 pound of a 50% barley, 50% alfalfa pellet per head per day for 14 or 21 days prior to breeding and for the first 16 days of breeding at Dubois, Idaho.

There were no significant differences among treatments in lamb production. These negative results with Rambouillets in contrast to the positive results from partially contemporaneous studies with Columbia and Targhee ewes at this station (1957-1959) suggest that the Rambouillets, believed to be better adapted to dry range conditions than Columbia and Targhees, may have been under more nearly optimum feed conditions for highest lamb production than the other breeds. Consequently supplementation did not increase Rambouillet lamb production. The different composition of the supplements given the ewes in the two experiments exclusive of TDN differences is another possible explanation for the different results.

The differences in lamb production among years were highly significant. Part of these differences was due to the depressing effect of vibriosis on lamb production in 1961. (AH 61-7)

c. Effects of Management and Length of Flushing Period Prior to Breeding on Lamb Production in Columbia Range Ewes.

Columbia ewes at Dubois, Idaho, were supplemented with 0.5 or 1.0 pounds of oats per head per day for 17 or 34 days prior to breeding. Oat straw was used to lower the condition of two of the treatment groups prior to administration of the oat supplement. Preliminary results indicate a year x treatment interaction on lamb production. None of the flushing treatments applied in the fall of 1960 resulted in a greater response than the unsupplemented control. However, in the fall of 1961, following fall rains which produced a good regrowth of grass prior to breeding time, the six flushing treatments increased lambing rates by an average of 6.5% more lambs born than the

untreated control. The best treatment (oat straw 34 to 18 days before breeding and 0.5 pound oats for 17 days prior to breeding) increased percent of lambs born by 16.9% above the controls.

This study will be continued another year in an effort to get more conclusive results. (AH bl-7)

2. Mating Behavior.

Variation in air temperature, wind velocity, cloud cover, precipitation, brightness of moonlight, type of artificial light at night (sealed beam spotlight or infrared illumination), age, inbreeding, body weight, semen score and previous use had no important influence on mating behavior as observed at Dubois, Idaho.

In one-sire pens Rambouillet rams appeared to be more active than the Targhees and Targhee rams were more active than the Columbias. Number of ewes in heat and individual ram differences independent of number of ewes in heat were the most important factors affecting mating behavior in the ram. The averages for various traits observed during breeding when one, two, or three ewes, respectively, were in heat are: teases/hour 0.95, 1.45, 2.31; mounts/hour 1.35, 2.14, 3.58; matings/hour 0.34, 0.55, 0.98; minutes lying down/hour 22.46, 17.59, 15.59; minutes eating/hour 9.46, 8.57, 8.50; and mounts per mating 4.75, 4.31, 4.63. Number of matings was moderately to highly correlated with the other mating behavior traits. Mating behavior traits were not significantly correlated with fertility. Stimuli such as initial introduction into breeding, number of ewes in heat and feeding had greater influence on mating behavior than the hour of the day or amount of light.

Mating behavior of the ram in the multi-sire pen was also studied. When a particular combination of rams was placed in a pen the dominance of one ram over another was quickly established. The dominant ram largely controlled the activity in the pen under most conditions, but became less effective in this regard when the number of ewes in heat increased. The presence of subordinate rams in a pen increased the total number of matings but reduced the average number of matings per ram below that of the pens containing only one ram. The average number of matings for the dominant ram in combination pens was just equal to the average number of matings in the single ram pens. The greater the dominance of one ram over another the less the total mating activity, especially the mating activity of the subordinate ram. Dominant rams were more successful in completing copulation than subordinate rams (6.3 versus 12.4 mounts per mating). Mature rams exhibited a greater degree of dominance over yearling rams and were more dominant over yearling rams than yearling rams were over other yearlings. Mature rams tended to be less dominant over other mature rams than yearlings were over yearlings.

In studying the mating behavior of the ewe it was found that ewes frequently initiated the first sexual contact by seeking out the ram. When two or more ewes were in heat simultaneously certain ewes would crowd other estrual ewes out of position in an attempt to gain the ram's attention. Means and standard deviations (in parentheses) for various mating behavior characteristics of the ewes were: times teased, 17.8 (7.0); times mounted, 25.2 (14.4); times mated 6.3 (3.8); matings first half of estrus, 3.9 (2.8); and matings second half of estrus 2.4 (1.7); hours first to last tease, 27.6 (13.9); hours first to last mount, 18.9 (8.5); hours first to last mating, 15.7 (9.1); hours first tease to first mount, 3.5 (6.8); hours last mount to last tease 5.0 (7.4).

Age had no significant effect on any of the above variables but was positively related to number of lambs born. The more highly inbred ewes had longer estrus periods than the less highly inbred ewes. The time interval from first tease to first mount was longer for the heavier ewes after accounting for association between age and weight. As the number of ewes in heat increased the numbers of teases, mountings, and matings per ewe declined as did hours from first to last mount, hours first to last mating, and matings first half of heat. Hours from last mount to last tease was the only mating behavior characteristic significantly correlated with number of lambs born. The times at which ewes exhibited first and last evidence of estrus appeared to be more closely associated with management routine than time of day per se. (AH bl-7)

3. Effects of the Light Environment on Reproductive Phenomena.

Effects of variation in the light environment on ovulation rate, embryo survival and gonadotrophic content of the pituitaries of mature ewes during the breeding season are being studied at Dubois, Idaho, in cooperation with Utah State University. Only preliminary results are available at this time.

The ewes were synchronized for estrus with intramuscular injections of progesterone in oil and subjected to continuous light, continuous dark or natural daylight (control) at about the time of the first post-treatment estrus. After 17 days half of the ewes in continuous dark were shifted to continuous light (dark-light) and half on continuous light were shifted to continuous dark (light-dark). The ewes were slaughtered at approximately 3 and 25 days gestation to obtain ovulation and embryo survival rates. There was some suggestion that continuous dark increased ovulation rate (2.21 per ewe) when compared to controls (2.08 per ewe). There was a strong indication that continuous dark increased embryo mortality (44.4%) when compared to the controls (22.2%). The dark-light sequence resulted in the lowest ovulation rate (1.84 per ewe) and the light-dark sequence resulted in the lowest embryo mortality (13.0%). No information is yet available on

pituitary gonadotrophins. This study is being continued. (AH 1-7)

4. Relation of Ovum Age to Ovum Recovery and Embryonic Age to Length of Embryo in Sheep.

The purpose of this study conducted at Dubois, Idaho, in co-operation with Utah State University was to determine the optimum time for most efficient ovum recovery in excised reproductive tracts, and to determine the effect of age on ovum recovery site and on embryo crown-rump length.

Percent recovery of ova related to time from first observation of heat to slaughter was: $2\frac{1}{2}$ days, 100%; 3 days, 88%; $3\frac{1}{2}$ days, 75%; 4 days, 66%; $4\frac{1}{2}$ days, 56%. The corresponding correlation was $-.998$. The percent of ova recovery from the oviducts of all ova recovered as related to time from first observation of heat to slaughter was: $2\frac{1}{2}$ days, 100%; 3 days, 95%; $3\frac{1}{2}$ days, 95%; 4 days, 76%; and $4\frac{1}{2}$ days, 0%.

The mean crown-rump length of embryos by age was: 23 days, 7.7 mm; 24 days, 7.9 mm; 25 days, 10.6 mm; 26 days, 11.2 mm; 27 days, 14.1 mm; 28 days, 15.4 mm; 29 days, 18.8 mm; 30 days, 20.0 mm; and 31 days, 21.8 mm. The corresponding correlation was 0.945. The regression of age on crown-rump length was 0.43 ± 0.015 . Observations suggest that once embryo mortality occurs at this early age, degeneration is very rapid and is accompanied by marked change in the color, appearance and consistency of the embryo. The length of apparently abnormal but not degenerate embryos did not differ appreciably from those classified as normal. It is concluded that embryo crown-rump measurements can be used in obtaining relatively accurate estimates of embryo age but are less useful than appearance in judging embryo normality. (AH 1-7)

5. Synchronization of Estrus with Injected and Orally Active Progestins.

An attempt was made at Dubois, Idaho, to evaluate the effects of length of injection period (12, 15 & 18 days) and the kind of hormone (injected or oral) on degree of synchronization and post-treatment fertility. The intramuscularly injected progestin was given at the rate of 10 mg per head per day. Sixty milligrams of the oral hormone was given per head per day for 14 days. These ewes were group fed.

The result indicates that the longer period of treatment (18 days) resulted in the best synchronization but the lowest fertility at the first post-treatment estrus (43.2% ewes lambing). The shortest injection interval (12 days) resulted in satisfactory synchronization and the best fertility at first post-treatment estrus (60.5% ewes lambing). The orally active progestin given in $1\frac{1}{2}$ pound of chopped grain

gave satisfactory sychronization with 61.4% of the ewes lambing to the first post-treatment estrus. The third post-treatment estrus was still fairly well synchronized and proved to be highly fertile in all treatment groups. The ewes were not mated at the second post-treatment estrus. (AH bl-7)

6. Natural Versus Electroejaculates for Predicting Fertility in Sheep.

It is a common practice to use the electroejaculator for collecting semen samples from rams for the purpose of predicting fertility. Heretofore no information has been available as to the relative merits of using naturally versus electrically ejaculated samples. An experiment was designed to make this comparison at Dubois, Idaho. The work was done in cooperation with Utah State University.

Preliminary results indicate that both semen quality and fertility predictability are somewhat higher for naturally ejaculated samples than for electrically ejaculated samples. This is probably due to the fact that ram response to electrical stimulation is extremely variable. Some samples closely approximate natural ejaculates, whereas other samples appear to be modified to varying degrees by accessory gland secretions. That is, the accessory glands are stimulated to secrete, but few, many or no sperm may be ejected from the ampulla and upper ductus deferens. A small percentage of samples are contaminated with urine. Also, the results suggest that the accessory glands and lower ductus deferens harbor degenerating sperm cells which upon electrical stimulation are flushed out in varying numbers by accessory gland secretion and appear in the ejaculate. The percentage of these cells relative to total cells is dependent to a large extent upon the number of sperm cells in the ampulla and upon the degree of evacuation. Thus, electrically ejaculated samples are lower on the average in concentration and motility and higher in pH and abnormalities than their naturally ejaculated counterparts. These results suggest that the electroejaculator should be used for semen testing only when natural ejaculation is impractical. When it is used the lower predictability should be understood and decisions made accordingly. (AH bl-7)

B. Environmental Physiology

1. Effect of Location on Productivity of Targhee Sheep.

Production data on Targhee sheep are being collected in Hawaii, at Dubois, and Moscow, Idaho; at Fort Wingate, New Mexico, and at Spooner, Wisconsin. Comparative data are available only at Beltsville at present. The Targhees were the most productive purebred sheep at Beltsville in 1961 as measured by the production index. The production indexes of the six breeds there were as follows: Targhee 79.0;

Columbia X Southdale 74.4, Southdown 71.2, Hampshire 71.1, Merino 61.8, and Shropshire 51.7. (AH b3-4)

2. Effect of Environmental Conditions at Four Different Geographic Locations on Fleece and Body Traits of Sheep.

The collection of data in the study to determine the effect of environmental conditions at four different geographic locations on fleece and body traits of sheep was completed during May, 1961. Data have been collected from Tifton, Georgia; Dubois, Idaho; Beltsville, Maryland; and University Park, New Mexico. Data are being summarized and analyzed.

Radioactivity determinations were made on fleeces grown at the four locations in 1959-60 in cooperation with the Agricultural Marketing Service and the U. S. Naval Hospital. High resolution gamma-ray spectrum measurements were made of individual fleeces, using an 8-in. diameter, 4-in. thick sodium iodide crystal detector. The scintillations produced were viewed by three 3-inch photomultiplier tubes, the output signal of which was fed into a 256-channel analyzer. The major gamma-ray emitter present in these grease wool fleeces was K^{40} . Since the suint or dried perspiration of the sheep is quite high in potassium content, K^{40} gamma-ray measurements may provide an estimate of the suint content. Cs^{137} , a fission product, was also found to be present in many of the grease wool fleeces. The Cs^{137} content of grease wool from individually fed rams from the four locations did not vary widely, with average values ranging from 17.7 to 22.5 gamma-ray emissions per second per pound. The group fed rams, which were fed feeds common to the location involved, showed large differences among the four locations, with average Cs^{137} values ranging from 0.7 to 43.4 gamma-ray emissions per second per pound for wool sheared in the spring of 1960. These values were 0.7, 3.6, 9.2, and 43.4 for New Mexico, Maryland, Georgia, and Idaho, respectively. Grease wool obtained in the spring of 1959 from the same six rams that were group fed at the Idaho location in 1960 was also measured in the plastic scintillation detector. The Cs^{137} content of 1959 grease wool from these rams averaged about twice as high for the spring of 1959 as for the spring of 1960. Thus measurement of grease wool fleeces may offer some unique advantages for surveillance of Cs^{137} levels. An individual grease fleece may reflect the effect of one year's consumption by the sheep. With a suitable detector the level of Cs^{137} gamma-ray emission can be determined nondestructively in a short time with no prior sample preparation required. (AH b3-8)

3. Effect of Light on Wool Composition.

Six Rambouillet rams were maintained at Beltsville in complete darkness from January 11 to March 17, 1961. A group of seven comparable

rams were kept as controls in normal daylight over the same period. The two lots of wool entirely grown and removed under the above conditions were tested for Electron Paramagnetic Resonance at the Wool and Mohair Laboratory, Western Utilization Research and Development Division, Albany, California. No difference was found between wool grown normally and wool grown in the dark. (AH b3-5)

C. Physiology of Wool and Fiber

1. Development of Mohair Follicles in the Skin of Angora Goats.

Observations of mohair follicles in the skin of Angora goats of various ages from McGregor, Texas, are being continued at Beltsville, Maryland, for (1) the study of follicular group populations, (2) the proportion of immature and mature follicles in the skin of the newborn, and (3) the influence of season and age on the behavior of follicles. Studies of fetal Angora goat follicles have been completed. Ratios ranged from 7 to 10 secondaries for each primary follicle. Thus each group comprised 21 to 30 secondary follicles, plus three primary follicles.

It is interesting to note that the follicular population of South African Angora goats, obtained through the courtesy of Grootfontein College, and undoubtedly chosen from selected kids and Angora does, showed ranges quite similar to those found in Texas animals.

Ziehl-Neelsen's acid fast procedure has been adapted for staining skin sections and found to serve as an additional tool in differential counts of the primary and secondary follicles of sheep and goats. (AH b5-1)

2. Blood Supply to Fiber Follicles of Sheep and Goats.

Since follicular activity depends on a normal supply of blood to the skin, it is important to know just when the follicle obtains its direct supply through the dermal papilla. In dairy goats and Karakul sheep, blood capillaries enter the papillae of the primary follicles between 90 and 100 days of fetal life. In the Angora goat entry is somewhat later, beginning apparently on or about the 100th day. After this blood supply has been established, gradual keratinization of the primary follicles and fibers takes place. In follicles that develop later, entry of the blood capillaries occurs at a time when the follicular bulb is large enough to house at least one capillary loop. In the dairy goats, some of the very small secondary follicles may lack a direct blood supply. Studies of Merino, Rambouillet, and Hampshire sheep indicate that genetic potentialities of follicular anlage determine not only the type and density of the fibers produced and the type of glands that enable the skin to carry on the necessary

metabolic processes, but also determine the blood picture of the skin at a given age and during a given season. The blood vessels of sheep and goats are arranged in three main layers and branch into smaller arterioles, venules and capillaries in response to the demands of a growing follicular population. (AH b5-1)

3. Effect of Temperature on Wool Follicle Development.

In a preliminary experiment in cooperation with the Texas Agricultural Experiment Station, pregnant Merino ewes were kept for 11 hours daily at a temperature of 105° F. for at least the three last months of pregnancy, while the control animals were kept outdoors from August to October at McGregor, Texas. Lambs born smaller than usual and apparently in response to the heat treatment of their dams (although some lambs did not show any deviation from the norm) had large follicles and fibers with coarse medullation. This is contrary to the usual histological picture in Merino lambs. A small male lamb from a treated dam had only one mature secondary follicle in proportion to 10 immature follicles as compared to the ratio of about 1:1 in a larger lamb seemingly unaffected by the treatment to high temperature. (AH b5-1)

4. Effect of Season on Mohair Follicles.

Postnatal biopsies taken in 1959 at McGregor, Texas, and studied at Beltsville, Maryland, showed a relatively higher incidence of resting or shedding primary follicles and a lower incidence of medullated fibers during the colder months. Supported by similar observations made of material obtained in 1960 and 1961, this picture would indicate the influence of season on primary follicles. As a general rule, the primary follicles have medullated fibers at birth and some of these persist following the first shedding, as well as in the succeeding cycles throughout the life of the goat. (AH b5-5)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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Physiology of Wool and Fiber

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AREA NO. 14 - SHEEP AND GOATS - NUTRITION AND MANAGEMENT

Problem. The cost of feed is the largest single expense in the production of lamb meat and wool. Information that would increase the efficiency of feed utilization, reduce feed costs and increase productivity through better feeding practices would help the sheep producer meet the cost-price squeeze. Such information will come from basic studies of the development and function of the rumen, together with an understanding of how nutrients are metabolized in the animal. Such an understanding will enable sheep producers to modify and supplement rations in ways that will result in maximum production of desirable meat and wool. Much of the success or failure of sheep enterprises depends on production practices. Producers need better methods of animal management for the reduction of lamb mortality and disease and parasite losses, also procedures for handling ewes during breeding, gestation and lactation, as well as other labor-saving procedures and devices for the routine handling of sheep.

USDA PROGRAM

This is a continuing program conducted by biochemists, nutritionists, and animal husbandmen, involving basic nutrition and ruminant physiology studies, as well as application of known and new principles, in the development of better and more economic feeding practices of farm and range sheep. Basic studies on physiology and feeding practices and known and new principles in a number of fields are applied to the development of more productive management practices for farm and range sheep. These programs are carried on at Beltsville, Maryland; Dubois, Idaho; and College Station, Texas, in cooperation with other Divisions of ARS, and in formal and informal cooperation with State stations of Delaware, Idaho, Maryland, Montana, New York, Oklahoma, Texas, and Utah. Studies on ruminant bloat contribute to the North Central regional project on the chemistry and physiology of bloat.

The Federal scientific effort devoted to research in this area totals 3.7 professional man years. Of this number, 1.1 are devoted to digestion and metabolism, 0.5 to forage evaluation and utilization, 1.6 to range and pasture management, 0.1 to management practices, equipment and facilities, and 0.4 to program leadership.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State experiment stations in 1961 reported a total of 23.0 professional man years divided among sub-headings as follows: Digestion and metabolism 2.1, concentrates 3.0, forage evaluation and utili-

zation 5.2, nutrient requirements 4.4, range and pasture management 3.1, and management practices, equipment and facilities 5.2. This research is currently being conducted in all four of the regions with research in three regions being coordinated through W-34, S-45, NC-27, and NC-63 regional projects. Four States and USDA (informal) are cooperating in studies on nutrition of range sheep through regional project W-34. One State is investigating the nutritional evaluation of forages for fattening suckling lambs through the regional project S-45. Seven States and USDA are cooperating in studies of the chemistry and physiology of bloat through regional project NC-27. Eleven States and USDA are cooperating on studies of the biochemistry of forage utilization by cattle and sheep through regional project NC-63.

Basic studies of rumen function and the metabolism of products produced by rumen microbial activity are of major concern in the research of the State experiment stations. Investigations on concentrates are concerned with increasing the efficiency of sheep production by formulating suitable rations for fattening lambs and by devising economical rations for maintaining breeding ewes. Investigations on forage utilization are also concerned with efficiency of use as influenced by trace mineral supplementation, grazing systems, various perennial and annual forages, and by factors in the rumen concerned with forage digestion. The quantitative requirements for and the metabolism and interrelations of various minerals, proteins, and vitamins are being evaluated. The use of hormone, antibiotic, enzyme, or other feed additives in improving growth and feed efficiency is a very active area of study. The relation of nutrition to animal disorders such as "stiff lamb disease," nitrate poisoning, and trace mineral deficiencies is receiving attention. The effect of prenatal nutrition upon prenatal and postnatal development of the young is also under study. Intensive systems of management on pasture for spring lamb production, as well as the effects of range management practices on the range plants and the grazing animals, are important areas of study. Improvement of management and facilities are being studied by evaluation of early weaning, creep feeding, supplement for wintering ewes, varying weights of feeder lambs and equipment such as scales for chute sorting and self feeders.

Industry and other organizations conduct sheep and goat nutrition research mainly in the fields of feed additives and ration comparisons with particular emphasis on developing and testing new products. The estimated activity in this area amounts to 10 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Digestion and Metabolism.

1. Metabolic Disorders.

Three sets of experiments were conducted at Amarillo and College Station, Texas, from the fall of 1958 to the spring of 1961.

A definite relationship existed between the dietary mineral intake and the occurrence of urolithiasis in fattening lambs. The addition of disodium phosphate to the basal diet proved to be calculogenic in all instances. The addition of calcium carbonate in the form of carbotech reduced the incidence of urolithiasis. Lambs fed diets high in potassium had less urolithiasis. A non-significant increase in the number of cases of urinary calculi was observed when either magnesium carbonate or steamed bone meal was added to the basal diet.

Results obtained from analyses of the blood and urine samples taken during the experiments indicated that changes in the dietary mineral balance significantly altered the mineral levels of the serum and the urine. Certain physiological relationships were observed between the dietary intake of calcium, phosphorus, and potassium and the serum and urine concentrations of calcium, phosphorus, and magnesium. The addition of disodium phosphate to the diet resulted in significantly higher levels of phosphorus in the serum and the urine. The increased concentrations of phosphorus in the serum and the urine were associated with a significant increase in the level of serum magnesium and a significant decrease in the urinary excretion of magnesium. Lambs receiving disodium phosphate in their diet had significantly lower levels of calcium in their serum.

The levels of serum phosphorus and magnesium were significantly decreased and the level of serum calcium significantly increased in lambs receiving diets high in calcium. Animals receiving the high-calcium diets had significantly lower levels of phosphorus in their urine.

Lambs fed the high potassium diets excreted larger amounts of magnesium in the urine which may have accounted for the lowered incidence of urolithiasis in these lambs.

A general reciprocal relationship existed between the urinary excretion of phosphorus and magnesium in these experiments. High phosphorus excretion in the urine was associated with a decreased urinary excretion of magnesium, and these conditions were apparently predisposing to urinary calculi formation.

The addition of ammonium chloride to the diet at a level of 0.5 oz. per animal per day reduced the incidence of urolithiasis. The prophylactic value of ammonium chloride in reducing the occurrence of urolithiasis was assumed to be due to the observed significant reduction in the urinary pH, which resulted in increased solubility of the phosphates. (AH b2-1)

Cooperative work on the physiological factors associated with ruminant bloat at Ithaca, New York, was terminated during 1961 due to transfer of the cooperating agent. Data are now being summarized and prepared for publication.

Cooperative work on the physiological and biochemical nature of ruminant bloat has been initiated with the Animal Husbandry and Dairy Departments of the University of Maryland. Forty-two cases of experimental bloat (39 in sheep, 2 in cattle, and 1 in goats) were produced by the simultaneous injection of the animals with a sympathetic nervous system stimulator and a parasympathetic nervous system inhibitor. Intensity of bloat varied from slight to severe. Experimental bloat also was produced by oral administration of L tyrosine.

Tyrosine in acid fermentations is readily decarboxylated to form the sympathomimetic drug tyramine. Other alkaloids existing in legumes are parasymphatholytic. Preliminary work with fractional extracts of green alfalfa and ladino clover indicates that these fractions may be involved in the natural production of bloat. The parotid and submaxillary salivary ducts were ligated in sheep to determine the effect of limited salivary excretion on bloat production when animals are grazing on legumes. No bloat was produced in either the treated or control animals. (AH b2-6)

2. Feeding Practices and Procedures.

Data obtained during a 4-year period on the long-term effects of feeding pelleted diets to sheep at Beltsville are being summarized. The following conclusions appear to be warranted. Weight gains of animals receiving ad-lib alfalfa hay pellets are substantially greater than those of animals receiving chopped alfalfa hay ad-lib. The increased gains appear to result primarily from increased feed intake. Weight gains of animals on restricted intakes of pellets appear to be similar to those of animals receiving equivalent amounts of chopped hay. Animals receiving pellets ad-lib have not displayed depraved appetite symptoms but animals on restricted intakes of pellets have consistently displayed depraved appetites. Death losses of animals receiving pellets ad-lib have been excessive but death losses of animals receiving restricted levels of pellets have been similar to that of animals receiving chopped hay and normal diets. Rumen volumes of animals receiving pelleted diets are similar to those of animals

receiving chopped hay. Certain ruminal musculature, such as the pillars, are not as well developed in animals receiving pellets but no clear cut differences in ruminal motility have been established.

Gross symptoms of parakeratosis have been observed in only one year out of four. Histological data over a 2-year period, however, indicate that ruminal epithelium can be abnormal in pellet-consuming animals without gross symptoms of parakeratosis. Intensive histological studies conducted during the past year revealed very little normal epithelium in the forestomachs of self-fed pellet animals with all sections revealing a parakeratotic type of epithelium. Changes in the epithelium of the forestomachs of animals receiving restricted levels of pellets were even more advanced than those of the self-fed animals.

One hundred head of ewe lambs were used on a feeding trial comparing alfalfa hay pellets with long hay during the winter feeding period. An equal weight of pellets was fed in place of long hay to one-half of the animals. Both groups received grass silage in addition to the hay or pellets. During a 128-day period, the lambs receiving the pellets gained 0.26 pound per day, compared with 0.15 pound per day for the hay-fed lambs. There were no differences in the grease wool weights between the two groups as yearlings. In two previous trials with ram lambs, grease wool weights were increased by pellet feeding in addition to weight gains. The results of the 3-years work prove that pelleting of the hay for replacement breeding stock can either result in increased gains or reduced feed requirements during the wintering period. (AH b2-5)

In an attempt to find a more economical and time saving method of feeding sheep in the winter feed lots at Dubois, Idaho, and at the same time maintain the sheep in satisfactory breeding condition, 500 ewe lambs (Targhee, Columbia and Rambouillet breeds equally represented) were divided into five treatments and fed alfalfa as follows: lot 1 (control) fed 4.5 pounds baled hay on ground; lot 2, self-fed 5.2 pounds high-quality pellets (17% protein) from green, fine-stem hay; lot 3, self-fed 5.2 pounds low-quality pellets (13% protein) from brown, coarse-stem hay; lot 4, hand-fed 3.4 pounds of the high-quality hay pellets; and lot 5, hand-fed 3.4 pounds of the low-quality hay pellets. The lambs averaged 77 pounds body weight at the start of the 112-day feed trial and final weights were 99, 140, 133, 117, and 116 pounds for lots 1, 2, 3, 4, and 5, respectively. Ewe lambs self-fed high-quality pellets yielded grease fleece weights 1.6 pounds heavier than the control lambs. Apparent dry matter digestibility was 57.7, 61.4, and 54.9 percent for long hay, high-quality pellets and low-quality pellets, respectively, as determined from a digestion trial. This study was conducted again in a similar manner in 1962.

Forty-six ram lambs were used in total digestion trials during 1958, 1959, and 1960 to relate gain and feed efficiency data to the apparent digestibility of some nutrient constituents of the ration (7/8 alfalfa and 1/8 oats, pellet form). In 1960 two digestion trials were conducted. In trial 1, individual feed intakes were permitted to vary in accordance with previously established average daily ad libitum intakes. In trial 2, individual feed intakes were restricted to 3 pounds per 100 pounds body weight. Correlations between feed efficiency (pounds of feed consumed per pound of gain) and dry matter digestibility were -.45 and -.63 for trials 1 and 2, respectively. Digestible gross energy was correlated with feed efficiency -.58 and -.72 for trials 1 and 2, respectively. (AH b3-9)

During years of adequate rainfall thousands of lambs are fattened on wheat pasture in Oklahoma and adjoining areas. Previous work at the Fort Reno Station has shown that lush wheat pasture on fertile soil will carry about five lambs per acre. To investigate the possibility of increasing this carrying capacity and study the degree of finish in fattening lambs, 319 Western feeder lambs were self-fed a mixed ration while grazing wheat pasture. The lambs were divided into three groups by weight, below 62 pounds, 63-72 pounds, and above 72 pounds. Sorting the lambs into three weight groups and self-feeding a complete ration, in addition to the wheat pasture, appears to offer several advantages: (1) Unless the heavy lambs are started on feed immediately they may reach market weight without sufficient finish, (2) the stocking rate per acre can be increased considerably, (3) the lambs on self-feeders will continue to gain in weight during inclement weather and, (4) practically all lambs will sell at top market price.

The acreage of peanuts in Oklahoma has increased considerably in recent years. Volumes of peanut hulls are now available and it was felt desirable to test their value in replacing alfalfa hay in a lamb fattening ration. Indications were that peanut hulls can satisfactorily replace from 50 to 90 percent of the alfalfa hay in a lamb fattening ration if the peanut ration is nutritionally adequate in other respects.

Comparisons of different ratios of concentrates to roughage and the effect of pelleting also were made. Pelleting increased the average daily gain with a ration composed of 45 percent milo, 5 percent molasses, and 45 percent alfalfa hay, but a slight decrease in gain was noted in three other comparisons. Pelleting increased the amount of feed required per hundred weight of gain in three comparisons out of four. A feed with a concentrate to roughage ratio of 1:1 produced greater gains with less feed per hundred weight gain than a ratio of 65 percent concentrate and 35 percent roughage. (AH b3-7)

The feed consumption of 122 lambs receiving green chop ad-lib from April 12, 1961, through completion of weaning on June 28 was determined. Each lamb was allowed 0.83 pound of creep feed pellets per day and also allowed to nurse its dam from 4 p.m. until 8 a.m. daily. Winter wheat forage was used as the green chop from April 12 through May 6 and orchard grass-Ladino clover forage from May 7 through June 28. All material was weighed into the feeders and all refused feed was weighed back once a day. Samples of all feed given and all feed refused were taken on a daily basis for chemical analysis. The average consumption of dry matter was 1.0 pound, per lamb, per day, which was equivalent to 8.3 pounds of green forage. Data on the green chop consumption of lambs after weaning is being summarized. (AH b3-11)

3. Digestibility Studies.

A complete pelleted ration with chromic oxide included at 0.5% was fed to six sheep on an experiment of Latin square design at Beltsville, Maryland, in cooperation with the Beef Cattle Research Branch. Comparison of dry matter digestibility as determined by total collection, chromic oxide ratio, and lignin ratio methods, showed close agreement between coefficients determined by total collection and chromic oxide ratio methods; the lignin ratio method resulted in low coefficients. These results were obtained when total feces were collected from each sheep over 10-day periods. Coefficients determined from single-day feces samples by the chromic oxide ratio method agreed well with those obtained by the total collection method. The standard deviation of single day coefficients was only 1.10. Chromic oxide recovery during the experiment averaged 100.7%; lignin recovery 90.2%. (AH b2-5)

B. Forage Evaluation and Utilization.

Sixty-five head of ram lambs were used to compare the feeding value of pearl millet silage (corn meal used as a preservative) with corn silage at Newark, Delaware. Gains of the lambs during the winter feeding period were equal on the two silages. Digestion coefficients for the millet silage were: Dry matter, 62.7%; crude protein, 41.3%; ether extract 72.4%; crude fiber 66.9%; and NFE, 66.6%.

The digestibility of Ambercane silage was compared with corn silage in digestion experiments conducted at the University of Delaware with sheep, rabbits, and cattle. Nutrients in Ambercane silage were less digestible than those in corn silage. The correlation found between silage crude protein content and digestible protein content was $r = 0.75$. Digestion coefficients were significantly correlated between rabbits and sheep for both silage dry matter and protein ($r = 0.98$ and $r = 0.93$, respectively). (AH b2-7)

The digestibility of sun dried and artificially dried crown vetch was compared with No. 2 alfalfa hay in a digestion trial experiment with sheep at Beltsville, Maryland. The TDN content on a 90% dry matter basis was 48.8, 41.0, and 44.6%, respectively, for the alfalfa hay, sun dried crown vetch and artificially dried crown vetch. (AH b2-8)

A comparative study was made of the in vitro digestibility of different forage species considered to be a major part of the diet of sheep on the U. S. Sheep Experiment Station summer range at Dubois, Idaho. Forage species included were slender wheatgrass, mountain brome grass, sedgegrass, wild aster, wild dandelion, sticky weed, wild carrot, lupine, sweet anis, and one-flowered sunflower, which were separately fermented with buffered sheep rumen inoculum. Proximate analyses were conducted before and after fermentation and changes in composition reflected the effects of digestion by rumen micro-organisms. Total volatile organic acid production was also determined. The results showed that with the exception of wild carrot, all forbs were higher in crude protein than grasses. No consistent difference was found between forbs and grasses in ether extract and nitrogen-free extract. The crude fiber content of grasses was above that found in forbs. The losses as a result of fermentation of crude protein, nitrogen-free extract, and dry matter were greatest from the forb species. Losses of crude fiber were not consistently different in grasses and forbs. Ether extract was observed to increase during fermentation for all species except the one-flowered sunflower. No definite relationship was indicated between the amounts of volatile organic acids produced and other factors studied. Quantity and quality of the nutrient intake of sheep grazing on the U. S. Sheep Experiment Station summer range are being investigated by the use of esophageal fistulated sheep and bagged sheep for total feces collection. Digestion trials are being conducted at early, intermediate, and late periods of the summer season. (AH b3-9)

C. Range and Pasture Management.

1. Range Management.

A range survey, initiated in 1959 on the U. S. Sheep Experiment Station summer range near Dubois, Idaho, was completed in 1961. A grazing management plan for the Station's summer range was developed from this survey and put into operation. Statistical analyses have continued on the survey data. Phenology, soil movement, and weather observation studies will be continued and grazing exclosures will be maintained. This work is being carried on in cooperation with the Intermountain Forest and Range Experiment Station and the University of Idaho.

Summer grazing studies in four 80 acre pastures on the Station spring-fall range were continued with ewes that had produced Hampshire X White-face lambs. The stocking rate was increased from 23 and 36 sheep days

per acre to 28 and 45. The average loss in body weight from July 3 to September 17 was 15 and 22 pounds per ewe, respectively. Forty-two percent of the available forage was utilized on the three major grasses in the pastures with the lower stocking rate and 68 percent at the higher stocking rate. The black-faced lambs were creep fed a grain-hay-molasses pellet from birth to weaning (July 3) at which time the average age was 87 days. After weaning, the lambs were self-fed pellets (as above) and topped and marketed in three groups at three week intervals. Individual weights, dressing percent, and carcass grades were obtained. In an attempt to produce a more uniform age lamb crop, the ewes were synchronized with progesterone and mated to Columbia, Targhee, Hampshire, and Suffolk rams in the fall of 1961. Grazing rate will remain the same in 1962 but the lambs will not be weaned as early, so will be placed in the study pastures with the ewes for part of the summer trial.

Methods of grazing management with sheep to permit optimum use of the spring, fall, summer and winter ranges are being investigated at the U. S. Sheep Experiment Station, Dubois, Idaho. Sagebrush-grass range has been improved by grazing management with no reduction in stocking. Spring rest with heavy fall grazing by sheep resulted in less sagebrush and more grass and other herbage.

Rotation grazing at 20 and 40 sheep days per acre was studied on sagebrush-grass range at the U. S. Sheep Experiment Station from 1940 through 1958. Half the use was in the spring and half in the fall at both rates. The highest rate of rotation grazing tested in this study did not damage the range. However, previous work indicates that this rate would have caused the range to deteriorate if the grazing had been continuous or at the same time each spring. Rotation grazing allowed heavier utilization of forage than is possible with continuous grazing. (AH b3-1)

One of the objectives for the high summer range management investigations is to determine the grazing habits and utilization of forages by non-herded compared to herded sheep. Weaning body weights of non-herded lambs were 10 and 8 pounds lighter than herded lambs on similar range during the 1960 and 1961 summer grazing seasons. The pasture lambs also had poorer type and condition scores and shorter staple length. The lower production of the pasture flock may be explained in part by their failure to move to better forage when not herded. These estimates are independent of type of mating, sex, type of birth and rearing, age of dam, days growth, and band in which they grazed.

Bi-weekly weights were taken on the non-herded flock in order to gain more information on growth curves of range lambs to aid in management. Eighty-two percent of the final weaning body weight was reached on the sagebrush-grass spring range before the lambs were moved to the high

summer range. Lamb body weights averaged 62 pounds on July 10 and 76 pounds at weaning time August 23. (AH b3-9)

2. Grazing Practices.

Studies on the effects of grazing sheep and cattle together have been continued at Beltsville. These studies are being carried out in cooperation between the Sheep and Fur Animal Research Branch, Beef Cattle Research Branch, and the Forage and Range Research Branch of the Crops Research Division. An orchard grass-Ladino clover pasture was laid out in 1961 in two replicates, each made up as follows: Lot 1 (1-1/2 acres) grazed by 2 beef steers; lot 2 (3 acres) grazed by two steers and 10 sheep; lot 3 (1-1/2 acres) grazed by 10 sheep; lot 4 (1-1/2 acres) grazed by 2 steers and 2 sheep; lot 5 (1-1/2 acres) grazed by 3 steers; lot 6 (3 acres) grazed by 3 steers and 15 sheep; lot 7 (1-1/2 acres) grazed by 15 sheep; and lot 8 (1-1/2 acres) grazed by 3 steers and 3 sheep. The animals were placed on experiment on May 1, 1961, and were on test for 163 days. One animal unit was removed from each pasture on June 23 because of overgrazing in the heavily stocked lots. The data indicated that the lower stocking rate was better than the higher level; that animal performance was better for the steers and sheep grazing together (1:5) than for the animals grazing separately; and that the animal performance was poorest in the lots with steers and sheep grazing together in a 1:1 ratio. Due to drought conditions during 1962, the data are too limited to warrant any conclusions. (AH b3-10)

3. Management in Relationship to Parasitism.

Studies on the effect of management practices in relationship to parasitism and gains of lambs have been continued at Beltsville. These studies have been conducted in cooperation with Animal Disease and Parasite Research Division. Four management systems were studied in 1961. The systems included; I, ad lib feeding of green chop to lambs in dry-lot; II, transfer of animals to a clean pasture at bi-weekly intervals; III, grazing of animals on contaminated pastures, plus therapeutic treatment with N.F. phenothiazine; and IV, grazing of animals on contaminated pastures, plus therapeutic treatment with purified phenothiazine. Lambs on treatments II, III, and IV were supplied with creep pellets ad lib until weaning while creep feed was limited for treatment I to that consumed by the pasture lambs. Average daily gains from April 12 through weaning were 0.45, 0.46, 0.37, and 0.39 lb. per day, respectively, for the four treatments. Observations on replacement lambs following weaning indicated that parasitism was insignificant in lambs on treatment I, light to moderate in lambs on treatment II, very heavy in lambs on treatment III, and heavy in lambs on treatment IV. Four management systems were also studied in 1962. These included, I, ad lib feeding of pellets to lambs in dry-lot;

II, pasturing of lambs on clean pasture separately from the ewes (lambs were allowed to nurse at night in dry-lot); III, grazing of animals on contaminated pastures, plus therapeutic treatment with purified phenothiazine; and IV, grazing of animals on contaminated pastures, plus therapeutic treatment with thiobendazole. Average daily gains from April 14 through weaning were 0.60, 0.53, 0.58, and 0.52 lb. per day, respectively, for the four treatments. Data to date indicates that parasitism is heaviest under system IV. (AH b3-11)

D. Management Practices, Equipment, and Facilities.

1. Lamb Mortality.

Studies on lamb mortality at Beltsville, Maryland, were discontinued at the end of the 1961 season. Lamb mortality during 1961 was 5.8% for the first 14 days following birth of the lambs. Abortions accounted for 6.5% of the losses, still-born lambs for 41.9%, and death losses during the first two weeks for 51.6%. Sixty-two percent of the lambs that died were from multiple births. Lamb mortality during the 1961 season was 65% lower than during the 1956 and 1957 seasons. This marked reduction has resulted principally from improved nutrition of the ewes during gestation and adequate attention to the ewes and lambs during lambing. (AH b3-6)

2. Purchased vs. Raised Replacement Ewes.

To study lamb and wool production of purchased versus raised replacement ewes under Southwest conditions, three groups of ewes were started on test at the Fort Reno Experiment Station during the springs of 1957, 1958, and 1959. Each group was composed of four breeding groups, two of which were raised and two of which were purchased. The first 20 ewe lambs to reach market weight (90 pounds) from both 1/4 Panama X 3/4 Rambouillet ewes, and straight bred Rambouillet ewes constituted the raised replacements. Both groups were sired by Dorset rams. The purchased ewes were two groups of 20 each of Southwest white-faced yearling ewes and were selected to represent the kind of purchased replacements usually available. Preliminary conclusions are as follows: The purchased ewes produced more fall born lambs during the first year of production but decreased thereafter. The one-half Dorset replacement ewes producing their second and later lamb crops displayed a greater tendency for both fall and winter lambing than comparable Western ewes. Western ewes that were part Columbia or Panama produced fewer fall lambs but more winter lambs than Rambouillet ewes. There was little or no difference in the birth weight or early rate of gain (birth to 50 lb.) of lambs produced by the raised or purchased ewes. The purchased ewes sheared more grease wool than the raised ewes, but the clean wool production was about the same. Mortality was higher among the raised ewes than among the purchased ewes. (AH b3-7)

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AREA No. 15 - SWINE - BREEDING

Problem: Improvements in the heredity of swine depend primarily on the intensity and accuracy of the selection that is practiced in choosing breeding animals and on the choice of a mating system that will maximize the rate of genetic improvement. Crossbreeding swine for the production of market animals has so proved its value that nearly 95% of the pigs marketed in the United States are currently some sort of crossbreds. Research with swine thus is faced with the dual challenge of devising breeding procedures that will increase further the advantages of heterosis or hybrid vigor generally shown by crossbred pigs, and also developing methods for increasing the effectiveness of selection within specific populations. It is essential, therefore, that experimental work on the effectiveness and practical usefulness of different breeding and selection procedures be continued to aid breeders in developing inherently more efficient strains of swine. Particular effort is needed on effective genetic means for producing pork with more lean meat and less fat without detrimentally affecting other production traits.

USDA PROGRAM AND RELATED PROGRAMS OF STATE
EXPERIMENT STATIONS AND INDUSTRY

The importance of swine breeding problems has resulted in the development of a closely coordinated research effort between the State experiment stations and USDA. Research is in progress at Beltsville, Maryland, cooperatively at Miles City, Montana, and the Regional Swine Breeding Laboratory with headquarters at Ames, Iowa. The Regional Laboratory includes projects at ten States. Additional research in swine breeding is conducted at State experiment stations primarily in the North Central, Southern and Western regions. This is a continuing program of applied and basic research conducted by geneticists for the purpose of elucidating genetic principles and developing effective breeding techniques that will increase further the efficiency of swine with respect to productivity and carcass value. Investigations on selection and breeding systems include work on the economic importance of performance traits, their heritabilities and phenotypic and genetic correlations. The results of such studies provide the basis for emphasis given to different traits and their underlying factors in evaluating different kinds of selection and systems of breeding. Traits of major interest include sow productivity, pig viability, growth rate, feed efficiency, carcass composition and quality of meat.

Also a cooperative project with the National Research Institute of Animal Husbandry, Copenhagen, Denmark, provides for studies of fiber diameter of samples of muscle tissue from pigs in the selection experiment for high and low fatness at Beltsville.

A grant with the College of Agriculture, Poznan, Poland, provides for investigations on red blood cell and serum antigens to establish the mode of inheritance and relative frequencies of these antigens in certain breeds of swine. Its duration is for five years, 1962 - 1966, and involves PL-480 funds.

The Federal scientific effort in this area totals 9.5 professional man-years.

State experiment stations in 1961 reported a total of 23.6 professional man-years.

Industry and other organizations have shown considerable interest in the results from research on development of inbred lines and a registry association has been established for recording pedigree information on various inbred lines of swine. However, there has been practically no research by industry or other private organizations concerning the effects of different breeding systems or the relative value of different selection procedures. Not more than 2.0 professional man-years are provided by industry for swine breeding research.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Genetics and Interrelations of Performance Traits

1. Genetic and Phenotypic Parameters.

The inheritance of teat number and its relationship to maternal traits was examined in nine years' data from the Minn. #1 population at Grand Rapids. Heritability was $.10 \pm .04$ by dam-offspring regression and $.23 \pm .20$ by paternal half-sib correlation. Regressions of various maternal traits on total teat number were small and not significant for the traits considered. Significant regression values of .27 pigs weaned and 11.70 pounds of pig weaned on functional teat number were obtained when the effect of number of pigs born alive was removed.
(AH al-17)

Heritability of litter size at birth was estimated in 1970 daughter-dam comparisons from three inbred lines of swine at the Minnesota station. The three estimates did not differ significantly at the .05 level from each other or from zero and the pooled estimate was $.03 \pm .07$. In Wisconsin data heritability of litter size at 154 days of age was .20.
(AH al-10 and al-17)

Estimates of heritability of daily gain from weaning to 140 days (or 154 days) were obtained from pigs on the Minn. #1, #2, and #3 breeds. No significant breed differences were found. A pooled estimate of $.28 \pm .06$ (1419 df) and $0.14 \pm .10$ (451 df) was obtained from all breeds by gross and intra-sire regression of offspring on dam. (The former estimate is thought to be the better in these data.) Heritability was no higher in the Minn. #3 than from the other 2 breeds. The former is a recent derivative from a very broad genetic base. Other estimates of the heritability of post weaning growth rate were .40 (Wisconsin), .17 and .22 (Missouri), and .20 (Iowa). (AH al-4, al-10 and al-17)

At the Michigan Station, data from 80 individually fed boars were analyzed to study the relationship between daily feed consumption and feed efficiency, efficiency being defined as gain in live weight per unit amount of feed consumed. Boars with the larger appetites tended to be the less efficient ($r = -.37$). This was true in spite of the fact that the boars with the larger daily feed consumption were the faster gaining boars ($r = .79$) and the faster gaining boars were the more efficient ($r = .29$). Heritability of feed efficiency in Iowa data was .70, based on differences among litters of four pigs. (AH al-14)

Genetic correlations obtained at the Minnesota Station for post-weaning growth rate with feed efficiency, litter size at birth and average pig weight in a litter at weaning were -.22, .06 and .47, respectively. At Wisconsin the genetic correlation between number of pigs in a litter at 154 days and individual pig weight at 154 days was estimated to be .24. (AH al-17 and al-10)

Heritabilities estimated at the Oklahoma Station for carcass length, backfat thickness and loin lean area ranged from .4 to .6, while estimates obtained at the Iowa Station for dressing percentage, backfat thickness at the shoulder, middle of the back and over the loin ranged from .47 to .63. Phenotypic and genetic correlations between feed efficiency and growth rate were estimated at .50 and .71 at the Iowa Station. In contrast, negative correlations of -.4 and -.6 were obtained between these two variables at the Michigan Station. (AH al-4, al-8, al-10 and al-14)

At Missouri heritability estimates by the intra-sire regression of offspring on dam were 1.01, -.17, -.10 and .15 for probed backfat thickness, weaning weight, conformation score and feed efficiency, respectively, and .83, -.06, .17 and .10 by midparent regressions. The realized heritability of probed backfat thickness from response to selection was .76. Estimates of genetic correlations were determined by the covariance between offspring and parents. Backfat thickness was genetically correlated with rate of gain by $.70 \pm .11$, with feed efficiency by $-.46 \pm .23$ and with conformation scores by $-.93 \pm .03$. Large standard errors were found for the other genetic correlations among the traits studied. (AH al-6)

2. Genetic and Environmental Trends in Three Control Strains.

Genetic and environmental changes between generations and years and changes in maternal effects associated with age of dams have been measured in a breed-cross and a line-cross control strain at Beltsville and Hamprace control strain at Miles City, Montana, using the repeat mating technique described by Goodwin et al. (1955, 1960). Four litter traits (litter size, and litter weight at birth and at weaning), and two measures of individual growth rate (140-day weight and daily gain from weaning to 225 pounds), have been studied in the three strains. In addition, six carcass traits (backfat thickness, percent fat cuts, percent lean cuts, percent bacon, length of carcass, eye muscle area) were studied in the Beltsville strains. Results for the litter traits are based on 4 generations and those for individual pig traits on 3 generations. Changes in genetic merit between generations did not appear important except for post-weaning growth rate which declined rather markedly in the Hamprace strain. Matings within generations differed significantly for 140-day weight and daily gain in the line-cross strain and for litter size at birth, backfat thickness, percent fat cuts, percent lean cuts and length of carcass in the breed-cross strain. The linear component of environmental changes among years was significant for 140-day weight and daily gain in the Hamprace strain, for 140-day weight and percent bacon in the line-cross strain and for backfat thickness, percent fat cuts and percent lean cuts in the breed-cross strain. Maternal effects associated with age of dams were not apparent for any of the traits in the Hamprace strain, but two-year old sows in the Beltsville strains showed important advantages over one-year old sows in litter size and weight at birth and at weaning and in post-weaning growth rate. (AH al-11 and al-13)

3. Genotype - Environment Interactions.

Three trials including 240 pigs from 3 lines of breeding were conducted at the Oklahoma Station to investigate the importance of genotype - environment interactions in feedlot performance and various carcass traits. The two management treatments were a self-fed free-choice shelled corn and simple supplement ration on pasture and a self-fed pelleted vitamin--antibiotic fortified ration on concrete. No significant interactions were observed. Pigs raised on concrete, generally grew faster, had more backfat, larger loin eye, heavier belly, higher dressing percentage and a higher yield of primal cuts than the pigs fed on pasture. Pasture raised pigs, on the other hand, were sounder on their feet and legs. (AH al-8)

4. Size of Muscle Fiber as Related to Differences in Fatness.

Samples of the longissimus dorsi muscle obtained in 1960 and 1962 from representative pigs of the high- and low-fat lines in the

Duroc and Yorkshire breeds at Beltsville were used by the Forsøgs-laboratoriet, Copenhagen, Denmark, to measure fiber diameter. In both breeds fiber diameter of samples in 1962 averaged higher than those in 1960, the respective averages being .073 and .068 mm. for Durocs and .081 and .076 mm. for Yorkshires. In both years high- and low-fat Yorkshire pigs exceeded high- and low-fat Duroc pigs, suggesting that a breed difference was present. Breed differences in both years suggest a genetic influence on fiber diameter. This primary work needs further study to clarify the picture regarding the relation of muscle fibers to carcass traits. (AH al-12)

Relationships between fiber size and muscle mass were studied at Nebraska. These studies indicated less promise for using muscle fiber size as a tool for selection for muscle mass than seemed likely from preliminary work. The need for accurate ways to estimate cell or nucleus number at an early age was a limiting factor. Biochemical work is needed in this area because of its importance to research in all species of meat animals. (AH al-7)

5. Pilot Experiments.

The 15th generation of a selection experiment at the Minnesota Station for 18-42 day growth in mice has been completed. Average weight gain in the selected line (S) has been 4 grams (40%). The observed improvement has agreed with a predicted value based on selection actually attained and an estimated heritability of 20%. Rate of improvement has been more rapid in later generations. Estimates of heritability were similarly higher in later generations. The increase in effective genetic variance is postulated to be the result of re-combinations. The cross of the S-line with the long inbred A-line has not improved by half as much as the S-line (the expectation assuming only additive gene action). To ascertain if selection had worked on the maternal component, the S-line was reconstituted from the original inbred foundation stocks. The relative performance of the original and reconstituted stocks agrees with the estimate of genetic improvement that has been made. Reciprocal crosses of the two line stocks indicate that change in maternal influence has been small, if any. Hence, relative improvement for the S and S X A mice suggests a degree of nonadditivity of gene action. (Minnesota - AH al-17)

At the Michigan Station, a randomly-mated and an inbred strain of rats were formed from each of a two-strain and a three-strain cross. As inbreeding increased, the difference in weight gains between the randomly-mated and inbred lines increased with the randomly-mated line outgaining the inbred line from 4 to 34 grams in the three-strain population and from 12 to 21 grams in the two-strain population. For each 10% of inbreeding, a reduction in gain of 4.4 grams was found in the two-strain inbred line and a reduction of 2.5 grams in the three-strain inbred line. (AH al-14)

At the Indiana Station the possibility of using potassium-40 counts as means of estimating lean body mass was explored. In this preliminary work 98 pigs were observed at 5 ages, starting at 54 pounds live weight and terminating at 200 pounds when the pigs were slaughtered for carcass observations. The correlation between total K-40 count and live weight was .93, while simple correlations of K-40 count with the weight of ham, weight of the loin, and loin eye area were .51, .57 and .40, respectively. (AH al-3)

B. Selection and Breeding Systems

1. Selection for Single Traits.

Selection for high and low fatness at Beltsville has been carried through 7 generations in two lines of Duroc pigs and through 5 generations in two lines of Yorkshire pigs. In addition, a randomly-selected control line is maintained in each breed by using 12 boars on 16 gilts as parents of each new generation.

In Durocs backfat thickness at a live weight of 175 pounds has increased from 1.49 inches in the foundation population to 2.01 inches or by 35% in the high-fat line and decreased about 18% to 1.22 inches in the low-fat line. Backfat thickness in seventh generation control line pigs averaged 1.50 inches. Realized heritabilities computed as the regression of generation means on respective cumulative selection differentials continued to suggest greater effectiveness of selection for high fatness than for low fatness, the two heritabilities being .72 and .46, respectively. When calculated in terms of deviations from the control, the heritabilities for the high- and low-fat lines continued to be more nearly equal, i.e., .63 and .58, respectively. Corresponding heritabilities for fifth generation high- and low-fat Yorkshire pigs were in both cases .36 when based on actual time trends, and .27 and .45 when the time trends were expressed as deviations from the control. These latter values are considerably lower than the corresponding ones of .53 and .72 for fifth generation high- and low-fat Duroc pigs. This suggests rather strongly that there is less genetic variation for fatness in Yorkshires than in Durocs.

Litter size and litter weight within the various lines differed little between 1961 and 1960. However, only 5 or 31% of 16 gilts bred in the Duroc high-fat line produced a litter in 1961, compared with 75% in each of the low-fat and control line Durocs, and 94, 75 and 100% in the three Yorkshire lines. Post mortem examination of three high-fat Duroc gilts revealed 9 partly decomposed embryos in one gilt and 11 and 14 in the other two. Any decline in reproductive fitness shown by this line as a result of its increasing fatness would thus seem to be more largely due to an increase in embryonic mortality than to a decline in ovulation or implantation rates.

Growth rate, as measured by daily gain from weaning to 175 pounds live weight, continued to be higher for low-fat than for high-fat Durocs (i.e., 1.44 vs. 1.38 pounds), whereas in Yorkshires high-fat pigs continued to excell low-fat pigs (i.e., 1.38 vs. 1.29 pounds).

Feed efficiency as measured by the amount of feed consumed per 100 pounds gain from weaning to 140 days of age continued to show substantial advantages for low-fat over high-fat pigs in both breeds. The respective averages for low-fat, high-fat and controls were 295, 328 and 304 pounds for Durocs and 295, 318 and 303 pounds for Yorkshires.

Carcass data continued to show selected lines diverging from each other and from the controls. Seventh generation high-fat, low-fat and control line Durocs averaged 2.06, 1.53 and 1.97 inches in backfat thickness; 28.5, 29.9 and 29.0 inches in length of carcass; 2.65, 3.94 and 3.68 square inches in loin eye muscle area; 37.0, 41.4 and 39.2% in yield of lean cuts; 17.2, 11.6 and 15.0% in yield of fat cuts; and 12.1, 10.6 and 11.2% in yield of bacon. Differences between 5th generation high- and low-fat Yorkshire pigs were in the same direction but smaller. High-, low- and control-line Yorkshire pigs averaged 1.86, 1.37 and 1.59 inches in backfat thickness; 30.7, 31.0 and 30.7 inches in length of carcass; 3.60, 4.06 and 4.01 square inches in loin eye muscle area; 40.2, 42.0 and 40.6% in yield of lean cuts; 14.3, 12.0 and 13.6% in yield of fat cuts; and 12.0, 10.8 and 11.2% in yield of bacon. (AH al-12)

At the Missouri Station, two generations of selection for low backfat thickness in two lines of Poland China swine have resulted in average decreases of 0.18 and 0.20 inches, respectively. Backfat thickness of second generation pigs adjusted to 175 pounds live body weight averaged 0.94 inches in one line and 0.89 in the other. (AH al-6)

At the South Dakota Station, selection for low backfat thickness in a Duroc line resulted in a decrease of .07 inches from 1.29 in 1960 to 1.22 in 1961. Backfat thickness adjusted to a live weight of 200 pounds has decreased by about .20 inches since selections were initiated in 1953. Carcass data suggest that there have been accompanying improvements in carcass length and loin eye area. (AH al-9)

The research in progress at the Iowa Station to study the response of swine to selection for a single trait in each of three purebred and three crossbred populations has shown relatively little differentiation and, as judged by comparison with the control lines, relatively little response to selection. The traits being selected for in the two sets of selected lines are increased litter size, increased growth rate and decreased backfat, with the control lines maintained by use of randomly-selected animals only. Further study of the selection differentials is in progress as the basis for possible revision of the design. High

level of disease is thought to be responsible for small selection differentials. (AH al-4)

2. Selection for Combining Ability.

Reciprocal recurrent selection programs at Beltsville, Maryland, and cooperatively with the Montana Agricultural Experiment Station at Miles City, Montana, are now in the fourth and fifth cycles of selection. The traits primarily considered in selecting animals for crossing are their dam's productivity, their own post-weaning growth rate and their own backfat thickness at a live weight of 175 pounds. Selection of animals for propagating each strain is based primarily on the performance of their cross progenies as measured by the size and weight of litters in which they were born and raised, their individual post-weaning growth rate, and in the case of the Beltsville project, also their carcass value as measured by yield of lean cuts.

Results obtained in the Beltsville project have shown some heterosis with respect to size and weight of litter and post-weaning growth rate. However, the advantages for crosses have been rather small and, except for litter weight at weaning, there is little evidence of an upward trend in the performance of crosses. Single cross gilts mated to control strain boars continued to show substantial advantages over controls in both litter size and litter weight and to a lesser extent in post-weaning growth rate. The advantages for litter size at weaning averaged 0.4 pig or 5.0% in 1957, 1.5 pigs or 20% in 1959 and 1.5 pigs or 19% in 1961. In post-weaning daily gain the advantages shown by pigs out of single cross dams averaged .07 pound or 5%; .05 pound or 4%, and .12 pound or 8%, respectively.

At Miles City, Montana, successive cycles of Hamprace x Yorkshire and Yorkshire x Hamprace crosses continued to show increasing advantages over contemporary controls in litter weight at weaning but showed little additional improvement in post-weaning growth rate. Starting with 1953 when the first reciprocal crosses were made, litter weight at weaning has increased at the rate of 8.0 and 7.6 pounds per year in Y x H and H x Y crosses, respectively, whereas in Hamprace controls it increased at a rate of about 3.6 pounds per year. There has also been some improvement in the productivity of Hamprace and Yorkshire sows selected to produce pigs required for the next cycle of crossing. The two groups of sows differed little in productivity when used for crossing as one-year olds, but Yorkshire "select" sows substantially excelled Hamprace "select" sows in each of the five years in which the two groups produced straight-bred pigs as two-year olds. The apparent lack of age of dam effects suggested by these results for the Hamprace "select" strain agrees with results of trials specifically designed to separate genetic from environmental changes in the Hamprace control strain, as indicated under A. 2 above. (AH al-11 and al-13)

A comparison was made at the Wisconsin Station between the productivity of sows from a reciprocal recurrent selection program and that of sows from a herd in which selection was for purebred performance only. In general, sows from the recurrent selection program exceeded sows from the other group but the results were not conclusive. (AH al-10)

In a revised reciprocal recurrent selection project at Oklahoma, one cycle ($1\frac{1}{2}$ years) has been completed. Selection is for crossbred sow productivity as measured on crossbred half sisters of purebred females which propagate the two lines. Discarding animals for other things such as rhinitis, crooked legs and backfat thickness reduced selection differentials for sow productivity factors. If no culling had been done for other items, selection pressure for litter size would have been about .5 pig greater and litter weight at 21 days about 6 pounds more. The gilts saved actually showed small negative selection differentials, which without prior culling would have been positive by about .2 pig for litter size and 6 pounds for litter weight at 21 days. (AH al-8)

3. Development and Evaluation of Inbred Lines and Crosses.

At the Iowa Station, the Minnesota M line of Poland China swine with an inbreeding coefficient of 90% is being utilized to establish a new subline by Cesarian techniques for comparison with other inbred Poland China lines, blood antigen studies and genotype - environment interaction experiments. At the South Dakota Station, full brother - sister matings within 11 sets of Yorkshire pigs resulted in the elimination of all but 3 of the stocks after 2 generations of such matings. In trials at the Michigan Station to test the effectiveness of intense inbreeding in evaluating potential sources of superior germ plasm, litters out of crossline gilts and sired by boars of a third line were compared with crossline litters out of inbred dams. The litters from crossline dams were heavier and larger at 154 days of age, but the carcass desirability was similar for the two kinds of pigs. Of the 5 inbred lines used in these trials, only 10 of the 20 sows and gilts bred to maintain the lines farrowed, compared with 12 of 15 crossline females that were bred to farrow in the same season. (AH al-4, al-9 and al-14)

At the Minnesota Station, progeny of 3-way cross boars (Minn. #3, Minn. #2 x Minn. #1) were compared with progeny of straight bred boars from these lines. Dams were comparable groups of Minn. #1's. The daily gain of 236 pigs sired by crossbred boars averaged 1.85 pounds, compared with 1.91 pounds for 221 pigs sired by inbred boars. Feed per 100 pounds gain was 372.8 and 371.2 pounds, respectively. Carcass data obtained on samples of pigs differed little between the two groups. The results thus show that the performance of pigs sired by crossbred boars is comparable to that of pigs sired by boars of the breeds from which the crossbred boars are constituted. (AH al-17)

The second year of an evaluation of the comparative performance of rotational crossbred pigs sired by boars of standard breeds with the Minnesota lines was completed. Crossbred pigs sired by Duroc boars were superior to pigs sired by Minn. #1 boars for growth rate, feed efficiency, and all measures of carcass performance. (AH al-17)

The following estimated contributions were made by various breeds to the Minn. #3 breed of swine: 31% Gloucester Old Spot, 20% Poland China C line, 14% Welsh, 12% Large White, 7% Beltsville #2, 6% Minn. #1, 5% Minn. #2, 5% San Pierre. Sixteen foundation animals contributed to breed formation. Estimated inbreeding reached 14% in the 5th generation. (AH al-17)

Data from 1256 litters were studied at the Oklahoma Station to determine the effects of line of breeding and sire on sow productivity as measured by number and weight of litter at birth and at weaning. Line averages differed significantly for some traits but no one line was superior to others in all seasons for any one trait. The results also showed no significant sire differences when sires were compared on the basis of their crossbred daughters' productivity records. (AH al-8)

Convergent improvement in a Hampshire line by addition of 2 to 4 outbred gilts representative of the breed has resulted in very slow changes in the line in performance and conformation traits. Top crosses exhibit hybrid vigor inversely as their relationship to the line increases. (AH al-9)

4. Environmental Influences as Related to Performance.

Inbred lines at the Iowa Station put through modified specific pathogen free (SPF) procedures showed increased productivity of dams. Respective averages for non-SPF in 1960 and SPF in 1962 were: 84.8 and 94.5 for percent bred, 69.1 and 87.6 for percent farrowed, and 76.8 and 85.2 for percent live pigs at 7 days. Crossbred SPF pigs transferred to a high disease level at 8 weeks showed almost equal growth rate with non-SPF pigs and required 15 pounds more feed/100 pounds gain than non-SPF pigs. The Eureka, South Dakota, field station has also been repopulated with SPF rotation-cross pigs. (AH al-4 and al-9)

At Nebraska, the performance of 172 crossbred SPF litters farrowed and raised in a central farrowing house was compared with 40 crossbred SPF litters farrowed and raised in individual houses. Pigs farrowed during the early half of any one farrowing period in the central farrowing house were significantly heavier at 56 and 140 days of age than those of the late half. No significant difference existed in the early and late half in individual houses. Pigs farrowed in individual

houses and fed to market weight according to age and size in groups of 50 grew more rapidly. Numbers of pigs alive at birth were low at all three Nebraska stations. A majority of gilts farrowed large numbers of mummified fetuses. Many complete resorptions occurred in late gestation. Despite the reproductive problems, the SPF herds at North Platte and Lincoln remained free of virus pneumonia and atrophic rhinitis. (AH al-7)

Selection differentials for rate of gain and backfat thickness were low in two Indiana inbred Chester White lines. Incidence of virus pneumonia was high. Disease in the Minn. #2 at Rosemount and Morris have importantly affected numbers of animals available for breeding in this line. A slightly less serious disease problem in the Minn. #3 also arose at Duluth. (AH al-3 and al-17)

Confinement and pasture management systems for swine were studied at Oklahoma. Results at 56 days indicated that death losses were fewer with confinement, but confinement gilts ate more feed and lost more weight than gilts on pasture. In post-weaning performance, pigs fed on concrete floors gained faster, required less feed per pound of gain, had more backfat, larger loin eye area, heavier bellies, higher dressing percentage, and a higher yield of primal cuts than pigs fed free choice corn and supplement ration on pasture. These differences were statistically significant. The lower cost of the pasture ration made the cost per 100 pounds gain considerably less on pasture than on confinement. Pigs on pasture were sounder on their legs and produced slightly leaner and longer carcasses than those raised in confinement. (AH al-8)

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AREA NO. 16 - SWINE - PHYSIOLOGY

Problem. Continued improvement in efficiency of swine production is dependent on new information regarding the physiology of growth and reproduction as well as environmental adaptation. Particularly in the field of swine fertility considerable knowledge is needed regarding the development of artificial insemination, including semen and ova preservation and storage. Fertility problems in boars and sows seriously plague the efforts of the industry to produce pork at lowest cost. Development of new genetic aids for improvement of swine requires additional understanding of the physiological processes, particularly those involved in the growth and production of lean meat.

USDA PROGRAM

This is a continuing program conducted by physiologists on basic and applied studies on the physiology of reproduction, artificial insemination, effect of hormones on growth and development and the physiology of growth and development, particularly with respect to the mechanisms involved in fat deposition, muscular development and inborn metabolic defects. No work in this area is currently in progress at Beltsville due to a vacancy, but the program will be reactivated when qualified personnel can be obtained. Cooperative studies on the physiology of reproduction are included in projects of the Regional Swine Breeding Laboratory at Missouri and Nebraska, with informal preliminary investigations in others when opportunities for them arise.

The Federal scientific effort on research in this area totals 2.4 man-years. Of this number, 0.1 is on physiology of reproduction, 2.0 on physiology of growth and development, and 0.3 on program leadership.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State experiment stations in 1961 reported a total of 11.2 professional man-years divided among subareas as follows: physiology of reproduction, 4.6; environmental physiology, 2.4; other physiology, 4.2. This research is conducted by stations in four regions, with the North Central, Northeastern, Southern and Western Regions providing 5.7, 0.5, 4.2, and 0.8 man-years, respectively.

At the State stations, work in the subarea physiology of reproduction is based on the thesis that increased reproductive efficiency in swine is dependent primarily on an understanding of the nutritional and physiological influences on ovulation rate and embryonic survival. Fundamental studies are underway designed to yield information on endocrine events occurring at the time of ovulation, and physiology of

the uterine tract conducive to maximum embryonic survival. The effects of levels of nutrition at various stages of growth and development on ovulation rate and embryonic survival are also being studied.

Stress factors under study in the subarea environmental physiology include high- and low-ambient temperature, optimum temperature and humidity at different stages of development, and interrelationships of environmental temperature with nutrition and environment. The effects of cooling of males and females on conception rate and prolificacy is also being investigated. Additional studies in this area, including design of housing and equipment, are being conducted in co-operation with Agricultural Engineering. These are reported under Unit 1, Agricultural Engineering Research.

State stations are investigating the influence of inbreeding and cross-breeding on physiological mechanisms affecting growth and fertility. One station is determining the time and rate of development of differences in carcass characteristics in barrows and gilts, and the influence of feeding low levels of hormones on sex-influenced growth pattern. Extensive basic research is concerned with the nutrition and physiology of the developing swine fetus. Changes in total serum protein and serum protein electrophoretic patterns during fetal development are being investigated and histological changes of the gastrointestinal tract as they occur during development of the fetus are being characterized.

Industrial participation in swine physiology research is conducted by pharmaceutical manufacturers, mostly in the field of feed additives and the administration of hormones with particular emphasis on developing and testing new products. It is estimated that approximately 25 professional man-years are expended by industry in this work.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Physiology of Reproduction

1. Selective Fertilization and Mating Behavior.

Multiple sires were put with different groups of females at the Nebraska station to study the frequency of multiple matings and mating behavior. Multiple mating occurred in 65% of all litters. Order of mating had less effect on the relative number of progeny per sire than the apparent physiological phenomena of selective fertilization. Observations on mating behavior indicated more sex drive by Hampshire than Yorkshire or Minnesota #1 boars. Animals with more sex drive tended to rank higher in reproductive capacity. When boars that ranked high in social order in their group were paired with boars of similar rank, they accepted one another as equals. Fighting was most vicious among pairs of low-ranking boars. (AH al-7)

2. Factors Influencing Estrus and Fertility.

Gilts at the Missouri Station, implanted with 400 mg. progesterone and 200 mg. estradiol on the 7th day of pregnancy, showed no improvement in embryonic survival (31%) over controls (32%). In another study, 22 sows were treated with Armour's Gonadotropin for control of estrus and ovulation. Of all recycled sows bred at the first estrus after treatment, nine were pregnant when slaughtered 25 days after breeding. Subcutaneous stilbestrol and progesterone estradiol implants failed to increase growth rate, but lowered backfat thickness. Previous investigations on the induction of superovulation in swine were continued with modifications of the type of hormone treatment employed. The injection of follicle stimulating hormone (FSH), pregnant mare serum (PMS), or human chorionic gonadotropin (HCG) at various stages of the estrus cycle failed to induce a significant increase in ovulation rate or litter size. The combined treatment PMS + HCG, gave an increase in litter size in a small sample of gilts. (AH al-6)

The effect of administering antibiotics at time of breeding on litter size was investigated in one experiment (29 animals). Alternate animals exhibiting estrus received a uterine flush of penicillin and dihydrostreptomycin. No improvement was noted in the treated animals. (AH al-6)

In one line at Nebraska, age at puberty ranged from 136 to 270 days. The correlation between age and weight at puberty was .82. Gilts fed a low energy ration at Missouri reached sexual maturity at a younger age and had more regular reproductive cycles than those on a high energy ration. Differences between the two groups in litter size at 25 days gestation were insignificant. (AH al-6 and al-7)

B. Physiology of Growth and Development

1. Hormone Treatments.

Poland China barrows were used at the Missouri Station to study the influence of subcutaneous stilbestrol and progesterone - estradiol implants on growth rate and carcass composition. Stilbestrol and high level progesterone - estradiol tended to reduce growth but the effect was small. Progesterone - estradiol decreased backfat thickness and tended to increase leanness. In another study a method was developed for measuring thyroxine secretion rate of swine. The average daily thyroxine secretion rate for growing finished pigs was found to be 0.46 mg. per 100 pounds body weight. (AH al-6)

2. Serum Cholesterols.

Total serum cholesterols were measured at Indiana in two groups of Chester White swine between 92 and 182 days of age during two seasons. No differences were observed between castrated males and intact pre-pubertal females. Means and variance were greater in the winter months than in the summer and early fall. Litter differences were indicated. Cholesterol values for all litters changed with increasing age in a similar (+ or -) manner. The direction of change was determined by season. The role of serum cholesterol in lipid metabolism and its relation to weight, gain, feed efficiency and carcass traits was studied. In general, the relationships to production and carcass traits were too low to be very useful for predicting performance by individuals. (AH al-3)

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AREA NO. 17 - SWINE - NUTRITION AND MANAGEMENT

Problem. The changing demands of the consumer to pork with a high proportion of lean is requiring major changes in the nutrition and management of swine. Furthermore, the use of materials other than lard has greatly reduced the demand for fat-type hogs. Along with the change in genetic makeup which must be made, basic facts concerning metabolic functions require investigation, and the basic nutritional factors which influence growth and carcass composition need to be identified and evaluated. These require information on quantitative and qualitative requirements at various growth stages and the changes in requirements to adjust for altered levels of other nutrients or modified environment. To meet the competition of other foods, including other meats, the nutrition and management of swine must constantly be aimed at improvement of feed and labor efficiency.

USDA PROGRAM

This is a continuing program conducted by biochemists, nutritionists and animal husbandmen, investigating basic and applied problems in swine production related to nutrition, metabolism and management. Work is in progress at Beltsville, Maryland, and cooperatively with the Agricultural Engineering Division, the Michigan Agricultural Experiment Station, the National Institutes of Health and the Food and Drug Administration. These studies contribute to the establishment of nutrient and mineral requirements and the relation of different components of the diet to each other; to the development of more efficient and economical rations; to the relation of genetic differences to dietary requirements; and to the role swine may have as an experimental animal for the investigation of health and dietary problems in man.

The total Federal scientific effort in this area amounts to 7.9 professional man-years. Of this number, 0.1 are devoted to digestion and metabolism, 1.5 to concentrates, evaluation and utilization, 1.5 to forage evaluation and utilization, 3.0 to nutritional requirements, 1.0 to management practices, equipment and facilities, and 0.8 to program leadership.

A research contract with Michigan State University, East Lansing, Michigan, provides for evaluation of certain feedstuffs as sources of fiber in modifying carcass quality factors and on efficiency and economy of swine gains.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State experiment stations in 1961 reported a total of 41.0 professional man-years divided among subheadings as follows: digestion and metabolism

2.9, concentrates 4.8, forages 3.2, nutrients 21.9, and management practices, equipment and facilities 8.2. This research is underway in all four regions, but the major effort is in the North Central (20.2 professional man-years) and Southern (15.4 professional man-years) regions.

Digestion and metabolism studies deal with the physiology of the digestive system, how it functions and factors which alter its function, and the basic biochemical reactions by which nutrients are metabolized. The efficient use of concentrates, feed grains in particular, is of primary concern because of the high proportion of concentrates in swine rations. The ways in which specific feeds and byproducts may be used, together with mineral, vitamin and amino acid supplementation required in the diet, constitute main lines of research.

Investigations on forages include ways to utilize them, including evaluation of specific forages as swine feeds, to provide cheaper vitamin and mineral supplementation and reduce energy intake with labor-saving self feeding. Self-feeding of diets high in energy leads to obesity and poor performance in brood sows and also brings many hogs to market that are too fat. This research has the purpose of utilizing fibrous feeds for more efficient production of swine in the production of high-quality pork.

The requirements of swine for specific minerals, vitamins, amino acids and energy (carbohydrates and fats) together with the interactions and toxicities which occur among them, constitute the main lines of swine nutrition research. Other areas of major work are: The use of feed additives (hormones, antibiotics, enzymes, etc.) in improving growth and feed efficiency; the effect of nutritional factors upon various stages of the life cycle (reproduction, gestation-lactation, etc.) and upon disease resistance and/or antibody formation.

The ways of managing the swine enterprise for more efficient operation are being investigated. The advantages to be gained by "early weaning" of pigs, ways in which farrowing times may be varied for marketing at more desirable times and for more efficient use of feeds such as pasture and combinations of pasture and drylot feeding, management of the sow in gestation and lactation, and parasite control through proper management are all under study.

Industrial participation in swine nutrition and management research is by feed manufacturing and pharmaceutical companies and is mostly in the field of feed additives and ration comparisons with particular emphasis on developing and testing new products. Some work is conducted on nutritive requirements, metabolic disorders and endocrine functions. This research activity, exclusive of quality control and ration calculation efforts, is estimated at 75 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Digestion and Metabolism

1. Source of Fiber (Michigan and Beltsville)

The contract at Michigan, on relationship of selected dietary fibers to rate and efficiency of swine gains and to production of lean pork carcasses, has been completed. The corn and cob meal diet gave the best overall performance producing intermediate rate of gain with carcass quality and feed efficiency at or near the top rating for the experiment. The diets which proved inferior included the corn meal (control) and other diets which used oats or wheat bran or alfalfa meal as principal sources of fiber. The results of this research have been submitted to the Journal of Animal Science for publication.
(AH a3-17 (C))

The study at Beltsville concerning use of harvested forage and fiber as management tools suggests that corn and cob meal may have practical applications for rearing breeding stock but is not as well adapted as alfalfa for gestation diets. (AH a2-4)

2. Digestion Trials.

In past years at Beltsville, investigations of metabolic processes and digestive capacities of swine have been limited by inadequate collection equipment. A metabolism cage has been developed which can be adjusted for separate collection of urine and feces from male pigs ranging in size from weanlings (56 days) to market hogs of approximately 200 to 225 pounds. The cage, harness and procedures evolved over a period of four years and are perfected to a degree that contamination or losses of excreta occur only about 2% of the time. The use of stainless steel feed and water pans plus floor screens and polyethylene collection equipment make these facilities equally valuable for trace mineral metabolism studies, balance studies, energy work or any research utilizing total collection of excreta. This development has increased the research scope at this station and expansion to its full potential can contribute to the total research effort in the field of digestion and metabolism of swine at other laboratories as well.

B. Concentrates - Evaluation and Utilization

1. Cottonseed Meal.

In the investigation at Beltsville, Maryland, directed at improvement in safety and use of cottonseed meal as a swine feed, enlargement of the heart has been such a consistent finding in autopsies of swine suffering from cottonseed meal toxicity that weight of heart in proportion to body weight has been accepted as the most reliable

diagnostic indicator of gossypol toxicity. Tissue analysis shows the heart enlargement to be due largely to increased water content and limited observations of sodium and potassium content of blood serum and heart tissue support the hypothesis that this edema is due to changes in cell permeability. Liver enlargement which is a frequent though less consistent toxic symptom is due to increases in both water and dry matter content.

The pigment, gossypol, in cottonseed has long been recognized as toxic to monogastric animals. However, many experiments have failed to show consistent correlation between toxicity of certain commercial cottonseed meals and their chemically determined gossypol content. Since gossypol is readily oxidized it seems logical to assume that anti-oxidants might affect physiological action of gossypol. Several rat feeding tests were conducted to measure the effect on gossypol tolerance of flavonol glycosides - antioxidants naturally present in cottonseed. Statistically significant variation in weight changes of experimental rats supported the conclusion that the flavonol glycosides, rutin and iso-quercetin, recently identified in cottonseed, might affect the level of gossypol which could be tolerated in diets of monogastric animals.

Further studies in collaboration with workers of S. R. R. L. at New Orleans showed that: cottonseed containing raffinose was reduced in lysine content and nutritive quality of proteins when heat was applied; 1% gossypol was less effective than 10% raffinose in destruction of lysine in cottonseed meal, but these concentrations were comparable in reducing level of free epsilon-aminolysine in cottonseed proteins; and finally the nutritive index of cottonseed meals (by the rat repletion method) showed poor correlation with total lysine but high correlation with free epsilonamino groups of lysine of the protein. (AH a3-16)

C. Forage Evaluation and Utilization

1. Forages in the Diet of Breeding Animals.

This experimental series at Beltsville concerns use of forage and fiber as management tools. An optimum method for managing female swine through growth and gestation should combine economy and high level of reproductive performance. Properly supplemented pasture or silage fulfill both requirements reasonably well and this experiment is designed to achieve similar results with a relatively high level of ground alfalfa hay (55 to 60%) to provide approximately 17 to 18% crude fiber in the diet. This alfalfa diet, fed ad lib. as a pellet, is compared with a meal diet based on ground ear corn, also fed ad lib., and a conventional corn diet which is hand-fed at a restricted level. In this study which involves management and nutrition the high fiber alfalfa diet (15 to 17%) was rather drastic for young swine and both growth and sexual maturity were retarded. However, these gilts had

nearly caught up in weight to those reared on the conventional diet at first farrowing and to date reproductive performance is nearly identical. Gilts fed ad lib. on the corn and cob meal diet (about 8% fiber) tend to grow at a somewhat slower rate than those on the conventional diet (about 4% fiber) but after being bred they gain more than is considered desirable. This seems to be borne out by a slightly but consistently inferior reproductive performance averaging about $\frac{1}{2}$ pig less per litter at 56 days of age. A final evaluation of these diets will require some additional compilation and analysis to determine whether lower costs per pound and savings in labor costs compensate for the additional pounds of total diet consumed by ad lib. feeding of medium and/or high fiber diets. (AH a2-4 and a3-17 (C))

D. Nutritional Requirements

1. Trace Mineral Requirements and Interrelationships.

The investigations at Beltsville have included studies on (a) the utilization and retention of zinc in pigs as influenced by the level of calcium in the diet and by dietary supplements of phytic acid and of ethylenediamine tetra acetic acid; and on (b) the interrelations between the amount of zinc stored in the tissues, the phosphatase enzymes in blood and tissues and purine metabolism as measured by the urinary excretion of end products.

Tentative conclusions drawn from the results of these studies are as follows: (1) On diets in which only zinc and calcium were varied, at zinc levels of both 30 p.p.m. and 80 p.p.m., less zinc is retained at 1.0% calcium than at 0.5% calcium as indicated both by zinc balance studies and by measurement of zinc stored in the liver. (2) On these same diets the alkaline phosphatase activity of the blood serum is correlated with the zinc in the liver. (3) The phosphatase activity of kidney and of gut in general follows the same trend as the alkaline phosphatase in the serum but appears to be less consistent in relationship to the zinc in the liver. (4) The phytase activity of the gut seems not to be influenced either by the level of zinc in the diet or by the amount of zinc stored in the liver. (5) The addition of ethylenediamine tetra acetic acid to a high calcium - low zinc diet has the same effect on the phosphatase enzymes as the addition of zinc, in some litters studied whereas in other, it appears to be without effect. (6) The addition of phytic acid to the diet appears to precipitate a zinc deficiency as indicated by lowered phosphatase activity in blood and tissues in some litters but is without effect in others. (7) The excretion of uric acid, both in total amount per unit of body weight and in proportion to the amount of allantoin, appears to be related to the level of zinc in the diet, that is, it is greater where there is some evidence of zinc deficiency. (AH a3-12)

2. Pantothenic Acid Requirements.

The final compilation and analysis of results from this study at Beltsville confirm the tentative recommendation, stated in last year's report, of 5.4 mg. of pantothenic acid per pound of complete diet for female swine during gestation. This is only slightly below the figure (6.0 mg.) given in the 1959 revision of N. R. C. Pub. 648 on Nutrient Requirements. Gilts which were reared on diets containing 4.5 mg. of pantothenic acid (P.A.) per pound of diet rarely showed deficiency symptoms but almost one-third of them failed to produce pigs. Survival rate of pigs from these gilts was fairly high but a large percentage of these sucklings had developed incoordination and irregular gaits by weaning time at 56 days of age. Since gilts receiving 5.4 mg. of P.A. per pound of diet had a higher survival rate of offspring which did not show deficiency symptoms it is apparent that the 4.5 mg. level of P.A. is borderline or slightly inadequate to support optimum reproductive performance and that a 5.4 mg. level is adequate and significantly superior to 4.5. Experimentation is completed and a report is being submitted for publication in the Journal of Animal Science. (AH a3-11)

3. Nutritional Status of Baby Pigs and Susceptibility to Infection.

Michigan researchers have been partially successful in rearing germ-free pigs. The original procedure, employing hysterectomy with the gravid uterus passed through an antiseptic lock into the sterile environment, has been largely replaced by Cesarean sections performed through the bottom of a plastic isolator cemented to the abdominal wall of anesthetized sows. The diets fed newborn pigs consisted of cows' milk fortified with vitamins and minerals, with or without added casein and butter, which were autoclaved before feeding. To date two pigs have been reared to seven weeks in a bacteria-free environment and 16 others to three weeks of age. A number of additional pigs have been reared in the presence of one or two species of bacteria.

Pigs raised under farm conditions were significantly heavier than the artificially reared pigs, but though minor differences were found in weight of various organs expressed in terms of body weight, relative organ weights were quite similar regardless of method of rearing or bacterial association in the environment. This project closed effective June 30, 1962, with the termination of Regional Project NC-13. (AH a3-14)

As reported last year, a similar project at Illinois was rendered inactive by personnel changes, transfers and completion of graduate projects. The decision to terminate NC-13 made it inadvisable to resume work and the project was officially discontinued in August, 1961. (AH a3-15)

E. Management Practices, Equipment and Facilities.

1. Portable Air Conditioner to Relieve Heat Stress at Parturition.

Cooperative studies with the Agricultural Engineering Division designed to appraise effects of temperature stress on sows at parturition and to evaluate methods of alleviating this stress have been included as adjuncts to nutrition experiments at Beltsville. The use of an air-conditioned maternity room ($70^{\circ}\text{ F.} \pm 5^{\circ}$) from the 109th day of gestation until pigs reached 3 days of age eliminated symptoms of acute heat stress and permitted reproductive performance in hot weather approximately equal to that obtained during cool periods of early spring or late fall.

Use of an ordinary one-room air conditioner, mounted on a wheeled frame and with flexible ducts for discharging cooler air at one or more farrowing stalls, was reported last year. The reduction of heat stress from onset of labor through parturition was estimated through observation of behavior but was not supported by any quantitative measurements. On June 8, 1961, three sows were occupying adjoining farrowing stalls with air temperature at 84° F. and 50% relative humidity. Sow #155 was showing restlessness indicative of onset of labor pains with a rectal temperature of 101.3° F. and respiration rate of 120 to 160. The use of 2 cold air ducts reduced respiration to 108 in 15 minutes, but the rate increased slightly in the next hour to about 130 then fell again to average about 100. This sow had a litter of 15 pigs born alive during the night. Sows #178 and #9887 showed no restlessness and use of 1 duct each maintained their respiration rate between 10 to 16 and 60 to 80, respectively, for one hour. At this time the duct assigned to #178 was removed and added to #9887. This change caused respiration rate for #178 to rise from 12 to 100 while #9887 fell from 60 to 28. These limited data illustrate the physiological changes obtainable from the modification of environmental factors such as air temperature and humidity. (AH a2-3)

2. Ventilation of Buildings for Summer Feeding.

Previous to installation of a ventilation system in building #208, seasonal differences were observed between summer feeding trials and winter feeding trials. Although genetic differences and dietary variables preclude any direct comparisons it seems noteworthy that daily gains from weaning to 225 \pm 10 lb. average between 1.40 and 1.55 lb. for summer trials previous to ventilation and approximately 1.60 to 1.75 lb. for winter trials and the two summer trials completed since ventilation was installed. These averages apply to our better diets with good quality experimental animals. (AH a2-3)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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- Martinez, W. H., Frampton, V. L., and Cabell, C. A. 1961. Effect of gossypol and raffinose on lysine content and nutritive quality of proteins in meals from glandless cottonseed. Agric. and Food Chemistry., 9, pp. 1, 64. Jan./Feb.

Forage Evaluation and Utilization

None

Nutritional Requirements

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Management Practices, Equipment and Facilities

None

AREA NO. 18 - FUR ANIMAL HUSBANDRY

Problem. Fur animal investigations are needed to obtain fundamental information on methods of increasing the productivity of ranch-raised fur animals including rabbits. Controlled research is needed on the development of superior lines, or possibly new breeds, for producing higher quality fur and better rabbit meat. The genetics of mutations of mink and foxes and the inheritance of factors for quality of fur and of meat in rabbits require continuous study. Feeding investigations are needed to determine nutritive requirement of various species and the most economical sources of feed to meet their requirements. Of special need is the finding of satisfactory substitutes for expensive raw meat. Low cost byproducts of the meat and fishing industries must be under constant study to develop practical diets. Successful husbandry of these animals requires extensive study of the peculiar characteristics of reproduction and their relation to productivity.

USDA PROGRAM

This is a continuing program and involves (1) genetic investigations of traits for use in improvement of rabbits, minks, martens, and foxes, (2) research on the reproductive performance of mink, including the effects of hormones and the process of lactation, (3) estimates of genetic parameters and maternal effects concerning economic traits in the production of fryer rabbits, (4) studies with regard to the priming process in fur bearing animals through investigations of the mechanisms involved in the growth of hair follicles, (5) research on the basic nutrient requirements and nutrient utilization by mink and the development of diets based on fish, meat and their byproducts for mink, fox, and marten, and (6) the relationship of nutrient factors and physical characteristics of the diet to rabbit production, including the study of various proteins.

The work is in progress at Beltsville, Maryland; Fontana, California; Ithaca, New York; and Petersburg, Alaska. Cooperation is maintained with Swarthmore College and State experiment stations of Alaska, California, New York, and Wisconsin. Close cooperation is maintained with the National Board of Fur Farm Organizations.

The Federal scientific effort devoted to the research in this area totals 4.5 professional man-years. Of this number 0.8 are devoted to fur animal breeding, 0.7 to fur animal physiology, 2.8 to fur animal nutrition and management, and 0.2 to program leadership.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State experiment stations in 1961 reported a total of 4.2 professional man-years divided among subheadings as follows: fur animal breeding 0.8, physiology 0.1, and nutrition and management 3.3.

Fur animal nutrition research, some of which is cooperative with USDA, is conducted by six stations. These studies are concerned primarily with determining basic nutrient requirements for mink and rabbits. Other studies seek to develop more efficient, low-cost rations, including dry diets. The causes, nature and control of fur abnormalities are also being investigated. Two stations, Alaska and Wisconsin, are conducting breeding research with mink and foxes in cooperation with USDA.

The research of industry and other organizations on fur animals is primarily with rabbits although some is done on nutrition of mink. It involves the utilization of rabbits in basic research studies for humans as well as livestock. Information regarding physiology, nutrition and breeding is obtained as byproduct of the large number of experiments. It is estimated that the portion of this research which might be specifically related to the improvement of the species probably would not exceed 15 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Fur Animal Breeding

1. Genetic Investigations of Traits for Use in Breeding, Selection, and Improvement of Meat Rabbits.

A study at Fontana, California, in cooperation with the University of California at Davis, entailed the further analyses of data from records at the Station, for estimates of genetic parameters and maternal effects involving economic traits. A genetic variance component analysis of litter size and weaning weight of New Zealand White rabbits was performed on the records of 1472 litters of random-bred New Zealand White rabbits over the years 1946-1960. The litter traits studied were number live born, number weaned, and total weaning weight. Foster rabbits were not included in the variance component analysis. Litters of zero live born were included. Litter averages were: number live born, 7.1; number weaned, 4.9; total weaning weight, 18.9 pounds. For each of the traits studied, the ratio of nonadditive genetic (dominance) variance to additively genetic variance was large. Interaction between genotype of offspring and maternal effect was postulated as a source of variance, the ignoring of which may bias the estimates of dominance variance upwards. Maternal effects accounted for about 20 to 25% of the variance in each trait.

An additional analysis of variance on the effect of season of weaning and age of dam on individual weaning weights, total litter weight and number weaned, was performed on 979 litters weaned in the years 1944 through 1959. The results showed that individual weaning weights were significantly affected by season of weaning and age of dam, and that there was a significant interaction between season of weaning and age of dam. For litter size neither season nor age of dam effects were statistically significant. However, average litter size was a little higher for young (first litter) does than for older animals. Total litter weight was significantly affected by season but not by age of dam, and there was no interaction between season and age of dam. The lack of significance between total litter weight and age of doe might partially be explained by the fact that individual weaning weights varied inversely with the number weaned and thus tended to cancel effects on total litter weights. The regression of individual weaning weight on size of litter was -0.017 pounds.

In cooperation with the University of California, a survey was made of the reproductive records at the U. S. Rabbit Experiment Station for the years 1946-1960. Weighted averages for number of rabbits born alive, number weaned, and total weaning weight, per litter (1472 litters, no foster young included) were 7.09, 4.86, and 18.90 pounds, respectively. Since the weighted averages for number born alive and number weaned were lower than expected, a by-year breakdown on the litter traits, with tests for outliers and analysis of variance on number live born per litter and number weaned per litter, was made. The variance of number weaned, using years as treatments, was significant but might be due to the variance in number born per litter being compounded in the number weaned category. With respect to number born alive per litter the average for one year (1953) was significantly smaller than the rest of the means. The average number weaned per litter for one year (1960) was significantly smaller than for the remainder of the means, and total litter weaning weight for the same year was significantly smaller than the remainder of the means.

An experiment to test crosses of the Fontana Station herd with other crossed lines of New Zealand White and with other breeds used in the production of fryer rabbits, has been initiated in cooperation with the University of California to search for an efficient breeding system for the production of fryer rabbits. Initiated work has not progressed to the "findings" stage.

In cooperation with Biometrical Services, Beltsville, Maryland, a study of maternal fostering in rabbits, designed to compare the growth and disease resistance of foster young with the dams' own young, was completed and included a crossnursing experiment to evaluate the importance of prenatal and postnatal effects. The data have been analyzed by analysis of variance techniques. Prenatal effects include one-half of the transmitted additively genetic (genic) effects; whereas, the

postnatal effects include only postnatal maternal environmental effects. Results suggested that genes of the newborn rabbit and prenatal environmental effects had no influence on mortality to 21 days. Postnatal maternal effects accounted for 5.4% of the variability in livability to 21 days. There was a slight indication of an interaction of prenatal and postnatal effects on mortality to 21 days, but none for mortality to 56 days when weaned. This interaction, when present, could be due to different genotypes ranking differently over different maternal environments, or could be due to a prenatal environment by a postnatal environment interaction, or to a correlation of means and variance. Postnatal effects were more important in influencing 21-day weights of the young than were prenatal effects. This was to be expected in view of the fact that a young rabbit eats very little other than the milk he receives from his dam to 21 days of age. Both prenatal and postnatal effects were less important in influencing 56-day weights than 21-day weights. There was some evidence for an interaction between prenatal and postnatal effects at 21 days, both for mortality and weight. Also, the gain in weight from 21 to 56 days of age was influenced to some extent by this interaction. Previous work with the University of California resulted in an estimate of heritability of 56-day weight in rabbits of about 23%. If this is correct, it seems that intrauterine environmental effects on 56-day weights are of little importance, since the prenatal effects accounted for only 13.5% of the variance in these data.

In cooperation with Biometrical Services, Beltsville, Maryland, an experiment has been initiated to collect data at Fontana so that reliable estimates of the heritability for 21-day weight and the gain from 21 to 56 days can be obtained. Initiated work has not progressed to the "findings" stage. (AH f1-1)

2. Genetics of Mink with Emphasis on Mutant Traits and Pelt Quality.

Experiments designed in the Genetics Department of the University of Wisconsin, in cooperation with the Sheep and Fur Animal Research Branch, to study all combinations of mutant genes affecting coat color are continuing in a herd of approximately 250 female mink. Mutant genes affecting characters other than color phase are becoming increasingly more important, and are incorporated into the breeding herd as available.

Breeding tests using a male introduced into the herd in 1959, exhibiting the "rex" character have shown that the male does not transmit a gene (or genes) for this character to his offspring. Thus, it would seem that the "rex" character in this individual is not a result of genetic changes, or if so the genetic potential for the character is not included in his germ plasm.

A new phase of genetics of the mink has been initiated this past year, a study of the inheritance of blood groups, and is already producing excellent results. The results of experiments in the Station herd are considerably augmented by field observation and cooperatively designed breeding tests on selected commercial ranches. (AH fl-2)

B. Fur Animal Physiology

1. The Influence of Hormones on Growth in the Mink.

The effect of hormones on weight gains in adult female mink was investigated at the Alaska Fur Station, Petersburg, Alaska, in cooperation with the Wisconsin Agricultural Experiment Station. Sixteen adult female mink that failed to whelp or raise their young during the previous breeding season were paired as to initial body weight, age and reproductive performance and were allotted, one each, to a treated and control group. Each treated animal received a subcutaneous injection of 2.4 mg. of progesterone and 24 micrograms of estradiol benzoate in 0.25 cc. of corn oil daily from July 23 through August 12, while the controls received 0.25 cc. of corn oil daily over the same period. All animals were supplied feed and water ad libitum. The ration consisted of 50% chum salmon waste, 20% flounders, 16% mink cereal, 2% wheat germ meal and 12% added water. Body weights were taken to the nearest 0.05 pound at the beginning and end of the experimental period. The treated females gained an average of 0.47 lb., increasing from an average body weight of 1.64 to 2.11 pounds, while the controls lost 0.08 pound, decreasing from an average body weight of 1.68 to 1.59 pounds. This difference in weight gain of the two groups was highly significant ($P < .01$). (AH f2-1)

2. Hormonal Control of Ova-Nidation.

A series of studies were made in cooperation with the University of Wisconsin on the hormonal control of ova-nidation and its delay in two species, the mink and the rat, with the objective of artificially increasing litter size in the former. The studies on the mink consisted of trying to hasten nidation, as measured by length of pregnancy, and increased litter size by treating pregnant intact animals with progesterone, estrogen, a combination of progesterone and estrogen or uterine trauma. An attempt was made to determine the endocrine condition of the mink during delayed implantation by studying the uterine response to trauma at this time. The studies on the rat consisted of trying to cause delayed nidation in the nonnursing intact, spayed, or hypophysectomized rat by administering high levels of progesterone or, in the case of a number of the last type of animal, by making hypophyseal autografts. In cases where delayed nidation was obtained in the ovariectomized rat, studies were made on the sensitivity of the uterus to trauma during the delay in nidation and the role of estrogen, the

deciduomal reaction, cortisone, and the adrenal gland in inducing ovulation.

The experiments on the mink indicate that estrogen alone, or estrogen given at high levels in combination with progesterone, prolongs the delay in nidation and reduces the litter size in the intact mink. Progesterone administration appeared to cause a hastening of nidation but the results were not very pronounced. Some doses of progesterone appeared to reduce litter size but most of the levels had little or no effect. Uterine trauma had no effect on nidation time or litter size in the mink nor did it succeed in eliciting a true deciduomal response during the period immediately after ovulation.

The studies on the rat show that the administration of high levels of progesterone in the absence of the ovaries or hypophysis brings about a delay in nidation until such times as minute quantities of estrogen are included in the treatment. Pituitary autografts cause a similar delay in implantation until such time as small amounts of estrogen are administered to the animal.

The uterus of the spayed progesterone-treated rat exhibiting delayed implantation responds to mechanical trauma with the formation of deciduomata. The deciduomal reaction and cortisone apparently will not induce nidation of blastocysts undergoing a delay in implantation as a result of spaying and injecting the mothers with progesterone. Estrogen will induce implantation of these "delayed blastocysts" in the adrenalectomized animal and, therefore, it does not seem to act through the adrenal gland as was once presumed to be possible. (AH fl-2)

3. Effect of Feeding Arsanilic Acid on Growth in Mink.

An experiment to test the effects of feeding arsanilic acid to mink was begun in July, 1961, at Madison, Wisconsin. Six lots (8 males and 8 females per group) were set aside for this purpose, receiving, respectively, levels of 0.00%, 0.01%, 0.02%, 0.04%, 0.08%, and 0.16% of arsanilic acid in their daily feed. It soon became apparent that these mink would starve rather than accept levels higher than 0.01%. Consequently, the four higher levels were eliminated. At pelting time (late November) there were no observable differences in the group getting 0.00% and 0.01%. These groups will be carried through the breeding, whelping and lactation periods to determine possible effects on reproduction of feeding arsanilic acid at this level (0.01%). (AH fl-2)

4. Mating Systems for the Marten.

A low level of fertile matings has been characteristic of marten raised in pens at Petersburg, Alaska. Because of the previous loss of three females from fighting during mating the males were placed

with females housed in adjacent pens every other morning, observed closely to insure compatibility and separated the same afternoon. The 1960 breeding season extended from July 10 to September 2 with 7 females mated 15 times and resulting in 3 litters born in 1961.

The same procedure was followed in 1961 with breeding from July 6 to September 5 resulting in 23 matings of 12 females. This increased breeding activity may be due to the addition of BHT to the ration about a year ago or to the age distribution of the females where some of the 3 and 4 year old females are just reaching sexual maturity. Better breeding did not result in increased production. Only two litters were born in 1962, however, one of them was whelped by a female with no record of having mated heretofore. Feeding and management practices for marten appear to be very successful but poor and inconsistent reproduction continues to be the paramount problem in the successful raising of marten in captivity. (AH fl-4)

5. Effect of Season on Reproduction in Rabbits.

In cooperation with the University of California, a survey of the breeding records at Fontana, California, over a period of 5 years, was made to observe reproductive efficiency and the use of forced matings at various seasons of the year. The results indicate a definite seasonal pattern, conception rates being highest, and percent of forced matings being lowest in April. Maximum fertility in the spring was also indicated by a maximum percentage of conceptions resulting from forced matings in April. Reproductive activity was at a minimum in the fall months of September and October. Pregnancies from forced matings average only 25.3%; ranging from 16.2% in October to 35.6% in April, as compared to an average of 70.9% for natural matings. (AH fl-1)

6. Effect of Season of Birth on Rabbit Mortality.

A study of the effects of season of birth on the incidence of enteritis, pneumonia, and combinations of enteritis and pneumonia, has been conducted in cooperation with the University of California on data covering a five-year period in the Fontana rabbit herd. Results indicate that births during the months of October, November, December, January, and February, produce the highest percentage of mortality due to enteritis, while births during the months of June, July, August, and September, result in the highest percentage of mortality due to pneumonia and in combinations of enteritis and pneumonia. (AH fl-1)

7. Relationships of Sex and Sex Ratios with Mortality in Rabbits.

In cooperation with the University of California an analysis of sex differences in enteritis mortality was made on data from 5123

rabbits in the Fontana Station herd. Chi square tests showed that sex differences were significant and that males are more likely to die from enteritis than are females. Mortality data covering a five-year period in the station herd are being analyzed and regressions of mortality on environmental temperature are being run to determine if there is a correlation between environmental temperature and the incidence of mortality.

Analyses of sex ratios at birth (secondary) and at weaning (tertiary) have been conducted in cooperation with the University of California, using data from the rabbit herd at the Fontana Station. Results of the secondary sex ratio analysis indicate that in litters containing one through six young, inclusive, females predominate while in litters containing seven to 11 young, inclusive, males predominate. Since these data represent only litters where there was no infant (i.e. before 14 days) mortality, the differential sex ratio must come about in utero. It is postulated that good prenatal environment produces large litters with more males than females, whereas poor prenatal environment produces small litters in which the differential mortality of male fetuses gives a preponderance of females among the live born rabbits. Analysis of the sex ratios at weaning indicate that in small litters (up to and including six born) there are fewer males than females. In larger litters, (8, 9, 10 or more born) there are more males than females. It would seem from this that in litters of six and fewer born there has been mortality decreasing the males before birth. Hence in those litters where few are born, but none die before weaning, the percentage of males weaned will be below 50% even though there has been no visible mortality in the litter. In larger litters (seven and up) there is an indication that more males than females are born (as one might expect) but as mortality occurs in these litters the extra males are eliminated. In this connection it is interesting to note that in most cases the percentage of males is higher at weaning than at 14 days of age. Therefore, mortality between 14 days and weaning at 56 days must be greater in females than in males. In other words the extra males die off early, if not before birth. (AH fl-1)

8. The Effect of Breeding Does at Various Intervals Following Kindling on Reproductive Performance.

An experiment at Fontana, California, designed to evaluate the effect of breeding does at various intervals following kindling, with regard to the effect on development of the young and productive life of the dam, continues to suggest that breeding at short intervals following kindling apparently shortens the reproductive life of the doe. Fifty-four does have been tested on four different breeding programs, one doe still remains on experiment. Since there is a tendency in commercial rabbit production to shorten the breeding interval to gain the advantage of greater total fryer production, the breeding interval has been reduced from 42 to approximately 25 days

following kindling in the station commercial test unit for further observations along this line. In addition, observations are being made on some animals using a breeding interval of 10-11 days following kindling.

The endocrine mechanisms controlling nidation and its delay in the mink and rat appeared to differ appreciably. These differences were noted and comparisons were made of the implicated mechanisms of delayed implantation and nidation in other species. (AH f1-6, f2-1)

9. Influence of Endocrine Factors on the Development of Hair Follicles within the Skin of Fur-Bearing Animals.

Information concerning the influence of hormones on the initiation and development of hair follicles in the fetus of fur-bearing animals is lacking owing to such factors as the survival rate of fetuses after surgical treatment, difficulties encountered when injecting materials directly into the fetus, and the type of skill required for this type of operation. Through cooperation of the veterinary staffs at Beltsville, Maryland, and at Ithaca, New York, mink fetuses were treated with hydrocortisone acetate to determine the role this hormone played in the development of hair follicles. Mink were mated only once at Ithaca to avoid superfetation and experimental treatment was scheduled for the 38th day of postnatal life. This is approximately the time when hair follicles are ready to form and the pituitary and adrenal glands are in the early stages of differentiation. Length of gestation is variable in the mink because of delayed implantation and it was found that the first series of fetuses were too young for study. A sufficient number of days were allowed to elapse before taking the second series. A little less than 50% of these survived after surgical treatment, a good percentage, however, when dealing with fetuses. These are now being processed for histological study. Results obtained from a pilot experiment with early postnatal stages of the rat at Beltsville indicated that hydrocortisone acetate, at the levels administered, retarded not only body growth but hair coat development as well. Further studies are in progress to determine whether smaller doses will produce the desired effects. Two additional hormones were used in the rat study, hydrocortisone sodium hemisuccinate and growth hormone (Somar-A) to ascertain the effect on skin as well as on the pituitary and adrenal glands. (AH f4-4)

C. Fur Animal Nutrition and Management

1. Development of Diets for Fur Animals Based on Sea Fish and Sea Mammals and Their Products.

Turbot is an abundant scrap fish in the Alaska area and offers possibilities as an ingredient of mink diets. An experiment was designed at Petersburg, Alaska, to test diets containing 25% of Turbot

in combination with other fish products. Six equalized treatment groups of 20 females each were fed through the reproductive cycle until weaning of their young in June. A basic ingredient in the diets was 50% of salmon heads from cannery wastes. Other treatment variables were combinations of Turbot with sea lion meat, whale meat and phenolic antioxidants. Approximately 100 bred females produced a total of 365 kits which is considered rather poor production compared with that obtained on other rations fed in previous years. Conclusion from the one breeding season is that the rations containing 25% Turbot in combination with 50% salmon heads are not up to standard for mink when fed during the breeding and reproduction period.

In previous years variable numbers of the mink kits fed through to pelting on fish waste diets have developed "wet belly" disease. The kits obtained from the feeding experiment described above were used to study the effects of various feed additives on incidence of this disease. Eight equalized treatment groups were fed from mid-August until December. The treatment variables were (1) control diet, (2) high level of carbohydrate, (3) high level of fat, (4) and (5) two levels of sodium phosphate, (6) an antibiotic, (7) diethylstilbestrol, and (8) ammonium chloride. General health and progress of the kits were excellent on all diets throughout the experiment. Incidence of "wet belly" was so low, even in the groups receiving stilbestrol or high fat, that no evidence of treatment effects on "wet belly" was obtained. Some minor treatment effects on growth and pelt quality were observed.

Poor production of the fox herd at Petersburg, Alaska, for the previous four years was thought to be due either to inbreeding or to the continued feeding of a diet composed of 50% raw salmon waste which is high in unsaturated fatty acids. The antioxidant BHT (Butylated Hydroxy Toluene) was added to the fox diet as of June, 1960. This was to determine if the poor production could be corrected without changing the breeding plan. No beneficial effects from this additive were observed in general health, growth, or fur quality in 1960. In 1961, 10 females who had received BHT were mated a total of 20 times and 8 of them produced litters as compared with 12 females mated 31 times with only 6 producing litters in 1960 before BHT was given. Pelts from the 1961 crop were of better quality than previous years and brought higher prices on the fur market.

BHT was kept in the diet throughout the year and continued in 1962. This year 10 females were mated a total of 24 times. Seven produced a total of 49 pups as compared to 8 producing 33 pups in 1961 indicating that the antioxidant may have some influence on litter size as well as production.

Menhaden press cake as a diet ingredient for mink during reproduction was studied in a feeding experiment at Ithaca, New York. Thirty-six

females were fed the standard station control diet while another 36 were fed a diet in which press cake, fat and water replaced horse-meat. Twenty-four of the control females whelped a total of 133 kits of which 98 were weaned at 6 weeks of age. Twenty-six of the females receiving press cake whelped 114 kits of which 67 were weaned. Thus, further experimental work with press cake showing more favorable results as a substitute for horsemeat would be necessary before recommending the use of this fish product in diets fed during the reproductive cycle. (AH f3-1)

2. The Relationship of Nutrient Factors and Physical Characteristics of the Diet to Rabbit Production.

A field trial to test the practical application of supplementing the basic rabbit ration with methionine, was completed at the Parker Farm, Bloomington, California, in cooperation with the U. S. Rabbit Experiment Station. Results indicated a negligible increase in weaned weight and feed conversion values in litters receiving methionine supplementation. The results of the field trial did not verify the results of previous controlled experiments conducted at the Fontana Station, wherein supplementary methionine significantly increased weaning weights.

An experiment to determine the effect of restricted availability of water on the incidence of enteritis and on growth in young rabbits was completed at Fontana, California. The effect was tested in successive litters from 54 mature female rabbits. Treatment 1 was the control with unlimited access to water, treatment 2 allowed ad lib. water consumption from 6:30 a.m. to 6:30 p.m. (12 hours), while treatment 3 allowed ad lib. water consumption from only 12:30 p.m. to 6:30 p.m. (6 hours). Water restriction commenced at the time of parturition and continued until the young were weaned at 8 weeks of age. Mortality and total production in the young were more affected by age of doe than by treatment. Significantly less enteritis and higher total production occurred in second and third litters than in the first. Limiting the availability of water to 6 to 12 hours per day significantly lowered individual weaning weights below those of young rabbits having access to water 24 hours per day. Indications were that the length of time water was available, rather than the actual amount of water consumed, was the important factor in impairing growth of the young.

An experiment investigating the effects of continuous and temporary feeding of oxytetracycline and chlortetracycline on weight gains, incidence of enteritis, and the control of diseases in rabbits, was completed. The data from this experiment are in the process of being analyzed and suggest that the feeding of these antibiotics is effective in increasing weight gains and reducing the incidence of enteritis in the young.

An experiment, in cooperation with Commercial Solvents, Inc., to study the effects of supplementary zinc-bacitracin (Baciferm) on weight gains and enteritis in young rabbits was completed. High and low protein rations, with and without the addition of Baciferm were used. Comparison of individual weaning weights and feed conversion, using an analysis of variance, showed no significant difference between any treatments. An analysis of variance of arcsin transformed litter-by-litter mortality indicated no significant differences between the Baciferm groups and the control groups for either nest box or enteritis mortality among the low protein fed animals, but there were significant differences in nest box and enteritis mortality in litters fed a high protein ration. On the overall tests (combining the data from both low- and high-protein rations) there was no significant nest box mortality, while the Baciferm-fed animals had lower enteritis mortality the level of significance being approximately 6%. (AH f3-2)

3. The Study of Various Proteins as Rabbit Feed.

To further study the tolerance of rabbits for cottonseed meal, an experiment was initiated at Fontana, California, utilizing degossypolized cottonseed meal at levels of 4, 7, 10 and 13% in the rabbit ration. Previous studies show that when used as a replacement for soybean oil meal at levels of 3, 5, 7, and 9% of the ration, degossypolized cottonseed meal is a satisfactory source of plant protein in rabbit rations, though there were indications of a depressing effect on total litter weaning weight, and increased mortality at levels of 7 and 9%. The present experiment will provide additional data using cottonseed meal at levels overlapping those of the previous experiment and verify growth stimulation at low levels and possible depressing effects of higher levels. (AH f3-4)

4. Investigations of the Basic Nutrient Requirements and Nutrient Utilization by Mink.

An experiment to study dietary niacin levels was conducted at Ithaca, New York, with 115 growing mink kits (110 males and 5 females). The experiment was designed (1) to determine the niacin requirement of growing mink, and (2) to verify previous work that showed mink were unable to convert dietary tryptophan to niacin. The levels of added niacin fed were 0, 10, 20, 30, and 40 mg. per 100 pounds of feed. Another group received no added niacin but supplementary tryptophan. The data showed that 10 mg. of added niacin was not sufficient to prevent death. None of the minks in this group survived. Survival and weights were as good on the 20 mg. level as on 40 mg. Results from the group fed tryptophan indicated that mink cannot convert this compound to niacin.

Six female mink which had been fed a purified diet the previous year were carried over during the reproduction cycle to study reproduction

performance on a purified diet. One of these females died early in the experiment. Of the five remaining animals, three did not become pregnant. Two whelped litters were seen but disappeared the day after whelping. Thus, no production was obtained on this purified diet. (AH f3-5)

5. The Development of Practical Diets and Feeding Practices for Mink.

Study of the effects of dietary supplements of the antibiotics, aureomycin and zinc bacitracin, on growing mink was continued for another season at Ithaca, New York. A total of 151 growing mink (78 males and 73 females) were distributed among three groups. Group (1) received aureomycin, (2) was given bacitracin, and (3) received no antibiotics. Again, as in previous experiments, the groups receiving antibiotics showed improvement. Average live weights and body length were greater for the antibiotic fed animals.

An experiment was conducted with 315 growing mink (139 males, 176 females) to determine the desirability of certain cereal mixtures in feeding growing mink kits at Ithaca, New York. The cereal mixtures tested were (A) the regular Wisconsin cereal mixture, (B) Wisconsin cereal supplemented with the antioxidant Santoquin and vitamins K, D, and E, (C) cooked ground wheat and a commercial mink cereal (Supersheen). Each of these cereals was tested at a level of 20% of the diet. Average weight gains of the animals showed a sex difference in response to the different cereal mixtures. Females gained best on the cooked ground wheat, while best results with the males were obtained on the commercial cereal.

In two previous experiments studies were made on the effects of added dietary salt on nursing sickness in mink. Added salt levels ranged from 0.2 to 1.44% of the diet (air-dried basis). There was some indication of heavier kits and reduced mortality of lactating females but results were inconsistent. In a continuation of this study during the 1962 reproductive season 193 females were allotted by chance to one of three experimental groups. All groups received the same percentage and kinds of meat and visceral products. Cereal composition differed in that Lot 1 received the Wisconsin cereal, Lot 2 cooked ground wheat, and Lot 3 a complex vitamin and mineral mixture closely approximating the commercial cereal "Supersheen." Each group was further subdivided into group A and B. One week after whelping all females in the B groups were given additional salt to the extent of 0.5%. Weight loss by females of Lots 2 and 3 during lactation were relatively light whereas that of Lot 1 was very heavy. Females in Lots 1B, 2B, and 3B lost less weight than their counterparts in the A groups. Kits in the 3A and 3B groups were heavier at birth and at weaning than kits of Lot 1 and those of Lot 2 were very much lighter and this difference was highly significant. Live kits whelped per female carried over averaged 2.50(1),

2.34(2), and 2.88(3). Although a total of 36 females died during the course of the experiment, only 2 of these died with symptoms of nursing sickness, one of which was in the 1A group, the other in group 1B. (AH f3-6)

6. The Effect of Diet on Fur Quality of Mink.

In studies at Beltsville, Maryland, and Ithaca, New York, the effect of varying the quality of the diet on the pattern of fur development has been determined both objectively and histologically. Mink receiving a diet poor in protein quality had fewer underfur hairs per guard hair than did those on the standard diet, while mink on diets of good protein quality showed histological differences, as evidenced by greater hair density in biopsy samples taken in August, and these differences persisted until pelting time, demonstrating the importance of high quality protein in mink diets. To determine whether animals with poor pelts could produce more dense pelts when changed to the better diet, mink were again placed on two different diets at 6 weeks of age and these diets were alternated in August, the critical period for hair growth. The biopsy samples taken from these experimental animals have been processed and histological analyses are now being made to learn if it is possible to stimulate the development of additional hairs of the underfur through change of diet during the critical period. (AH f4-3)

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AREA NO. 19 - HORSE HUSBANDRY

Problem. The growing use of light horses for use of pleasure suggests a need for research on the applications of breeding principles to their improvement and the use of selection based on record of performance. A balanced program would also require the determination of the physiological basis for record of performance, the development of practical methods for measuring performance in the field, studies on the physiology of reproduction in the horse and investigations regarding nutritional requirements of pleasure horses.

USDA PROGRAM

The USDA has no active program regarding horse husbandry.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State experiment stations in 1961 reported a total of 0.9 professional man-years. Two stations have active research in horse husbandry. The California station is determining blood types in horses, and the Delaware station is studying the effect of form of roughage on the reproductive performance of mares.

The horse industry has provided grant funds to some universities particularly in the field of diseases and to some extent in regard to nutrition. Some pharmaceutical manufacturers utilize horses in hormone production and conduct certain experimental activities regarding these procedures. Not more than one and possibly two professional man-years can be considered as research in this area by industry.

AREA NO. 20 - PRODUCTION INFLUENCES ON ANIMAL PRODUCTS

Problem. Pork, beef and lamb meat are excellent protein foods and most American diets are built around them. However, these meats are each criticized by the consumer for too much fat covering, lack of a bright red color, tenderness and flavor. The choice cuts and kind of meat are directly reflected in the demand and in the price of the product. Similarly, milk, eggs, poultry meat, wool and fur are demanded by the public in a high relationship to the desirability of their traits whether they be nutritive or functional. Many of the production practices directly affect the characteristics of animal products. Breed differences in butterfat and color of milk, nutritional effects on color of egg yolk, environmental stress on strength of wool, castration effects on flavor, color and tenderness of meat are well known production influences on animal products. Many other effects of production practices, however, are not so well understood but may be of considerable economic importance. Effective measures of evaluating quality and quantity differences are very important parts of this effort.

USDA PROGRAM

This is a continuing program conducted by food product technologists, wool and fiber technologists, biochemists, chemists, physiologists, statisticians, and animal husbandmen engaged in both basic and applied research designed to develop methods and information which will be useful in evaluating quality and quantity of animal products and will aid in livestock production. Research on beef, veal, lamb and pork is directed at the influence of selection and breeding, nutrition, physiology, management, and other production variables on carcass and meat quality. Standards are being applied and adapted for appraisal of slaughter animals, of carcasses, and of meat cuts. The objective of the work with poultry and eggs is to ascertain those factors of nutrition, breeding, and management which contribute to the initial quality of poultry products and their capacity to retain that quality. Studies with wool, fur, and fiber are conducted to determine the physical, chemical, and biological structures and properties of wool and other animal fibers as influenced by production factors. Research on humane slaughter was initiated to develop information and techniques on preslaughter handling, restraining, immobilizing, and dispatching of hogs, cattle, and sheep, in order to determine the most effective procedures for meeting the requirements of the humane slaughtering law and the influence of the effect of these procedures on the quality of the meat. The work is conducted at Beltsville, Maryland; Dubois, Idaho; Fort Wingate, New Mexico; and in cooperation with eight State experiment stations. Cooperation is also carried out with the Eastern and Western Utilization Research and Development Divisions, the

Human Nutrition Research Division, and the Market Quality Research Division.

The Federal scientific effort devoted to research in this area totals 16.4 professional man-years. Of this number 5.4 are devoted to beef, 1.3 to lamb, mutton, and chevon, 4.0 to pork, 1.0 to poultry and eggs, 1.7 to wool, fur, and fiber, 1.6 to humane slaughter, and 1.4 to program leadership.

Contract studies were completed during the year with the State Experiment Stations of Nebraska and South Dakota. The work in Nebraska was initiated to study relationships of certain live animal and carcass characteristics. At South Dakota the studies estimated the genetic and phenotypic relationships of carcass characteristics, growth, and conformation traits. Each of these studies constituted funds equivalent to .1 professional man-years.

A contract is in progress with the Wyoming State Experiment Station regarding the evaluation of lamb carcasses. Funds supporting this contract amount to .2 professional man-years.

A grant with the Polish Academy of Sciences in Poland provides for studies on the color of pork as influenced by heredity, sex, age, feeding, and management. Its duration is for five years (1960-1964) and involves PL 480 funds with \$42,784 equivalent in Polish zlotys.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State experiment stations reported a total of 17.9 professional man-years of which 7.7 are on studies relating to beef, 3.1 lamb, mutton, and chevon, 2.8 pork, and 4.3 poultry and eggs. Comparisons are being made of grass fattening, drylot fattening, or combinations of these, as influences on carcasses and meat characteristics. Studies are being conducted on varying the length of heavy silage feeding preceding finishing with a high energy ration, creep feeding versus no creep feeding during the nursing period, and various combinations of ration ingredients with and without adjuvants. Research is in progress on the influence of ratios of protein to energy and total feed consumption on carcass characteristics of swine. Still other studies are on the evaluation of various criteria of selection for superior meat type swine. Research on egg quality includes work on the causes and prevention of blood and meat spots and undesirable yolk coloration. The effects of different egg washing techniques on interior quality are also being evaluated. Studies have been undertaken on the effect of nutrition and management on chicken and turkey carcass traits, such as skin pigmentation and a desirable amount of fat. A number of breeding projects contributing to regional research projects are designed to determine the effectiveness of selection and improving carcass

traits and the effect which selection of one carcass trait has on other carcass traits. Several stations are studying the pattern of growth in different breeds and crosses of sheep as affected by feed, sex, castration and type of birth.

The activity by industry in the field of animal products is generally in the field of product processing and marketing. There are a few studies regarding the influence of production practices on product characteristics. One of the larger packing companies is carrying out an extensive beef improvement program including evaluation of carcasses for production of muscling, absence of waste, desirable ratio of fat to lean, and tenderness. Also, the packing industry cooperates extensively with publicly supported experiment stations in the grading and evaluation of carcasses resulting from various nutrition and management studies. Several textile mills conduct work on wool traits in sheep, including clean yield, fiber diameter and fiber strength. The number of professional man-years involved in industry effort on this area is estimated as 4.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Beef

1. Tenderness.

This research is being conducted at Beltsville and in cooperation with the Agricultural Experiment Station of Texas A. and M. Work was continued on variations in content of individual free amino acids in muscle tissue and their association with tenderness. A statistical study has been made on data from 209 animals. Considerable variation was found in animals from different sources. No correlation was found between the relative amounts of leucine-isoleucine and panel tenderness score on beef samples from dual-purpose steers averaging approximately 22 months of age in tests at Lewisburg, Pennsylvania. Samples obtained from the breeding experiments at Front Royal, Virginia, and Miles City, Montana, showed correlation coefficients of .35 and .36, respectively. Beef from Beltsville experiments in nutrition showed a correlation coefficient of .56 in relation to panel tenderness score. These results indicate that the relationship between the relative amounts of certain free amino acids in meat serum and tenderness is not as simple as one might hope. (AH d4-6)

A recently developed instrument modification for testing tenderness of meat samples referred to as Slice Tenderness Evaluator (STE) has been used to test meat slices of roasts from 74 beef animals. It was noted that higher correlations with panel tenderness score were obtained when the meat was tested parallel to the muscle fiber orientation than when tested perpendicular to the muscle fiber (with the

grain rather than across the grain). Although the shearing action of the device was related to subjective tenderness evaluations, the puncturing values added significantly to the overall value of the measurement. Preliminary observations suggest the existence of tenderness differences among the dorsal, medial and lateral locations of the loin-eye muscle of the 9-10-11 rib cut.

It has been suggested in a study of 27 beef roasts that the internal meat temperature at which the roast is served to the panel has little or no effect upon the panel members to render similar findings as regards palatability characteristics. The panel was equally effective in scoring meat samples served either warm or chilled. (AH d4-4)

The study of collagen content and its relation to tenderness was continued at Texas A. and M. The results showed that the Longissimus dorsi muscle contained less collagen nitrogen than the Biceps femoris muscle in the raw steaks and in steaks cooked to final temperatures of 61° and 80° C. The rates of conversion of collagen to gelatin were similar in both muscles. There were large variations among animals in collagen nitrogen content and in the percentage transformed to gelatin during cooking. The trend of panel scores and collagen content were toward increased tenderness with increasing temperature for each of the two muscles. (AH d4-5)

2. Composition.

Measurements for predicting actual fat thickness and loin-eye area have been summarized on approximately 256 cattle. Ultrasonic observations of lean depth made at two, three, four, and five inches off the midline over the 12th rib of the cattle, correlated significantly ($P < .01$) with the traced loin-eye area. Simple correlation coefficients were .30, .30, .29, and .31, respectively. Higher simple correlations between ultrasonic fat measurements and actual fat thicknesses on these cattle were .46, .61, .60, and .55 for the two, three, four, and five-inch locations, respectively. At a point three inches off the midline, the ultrasonic fat and lean measurements were both significantly related to actual fat thickness with a multiple correlation coefficient of .74. Multiple correlations at other locations were slightly lower. The only ultrasonic measurement location of significant importance in the regression of ultrasonic measurement on loin-eye area was at a point four inches off the midline. The multiple correlation coefficient for this relationship was .80.

The chemical determination of creatinine content of the blood of slaughter animals is being studied as a possible method for determining live animal composition. An analysis of the data from 180 cattle obtained over a five-year period, shows that rations and years accounted for 42.7 and 32.0% of the total variation in creatinine content. Sex was a relatively unimportant source of variation. (BS 3-34)

stilbestrol. The paired 9-10-11 ribs were used as samples. (AH d4-7)

c. Effects of Sex.

A study of certain meat quality factors in beef samples from 10 pairs of identical twin bull calves, consisting of 10 bulls and 10 steers all slaughtered at approximately the same weight, was made. A general statement from this analysis is that steers had smaller rib eye areas, less weight of preferred cuts, less total lean and more fat than bulls. Steers had more tender meat as determined objectively by the Warner-Bratzler shear and subjectively by a panel of trained judges, had more juicy meat that was richer and the meat was brighter colored. (AH d4-7)

d. Effect of Ration.

A summary was made on data collected over a two-year period on 54 steers fed corn supplemented rations. Steers fed corn plus corncob meal had distinctly larger average pancreas than those fed shell corn plus Vitamin A. Slaughter weight was inversely related to pancreas weight in these rations. Steers fed shelled corn plus 10% soybean meal had slightly greater primal yields than steers on the other two rations. Steers on corn plus corncob meal ration had distinctly larger eye muscle areas both years. Steers fed shelled corn plus Vitamin A had slightly greater percentage of separable lean both years. (AH d4-7)

B. Lamb

1. Tenderness.

The trained panel evaluation and the Warner-Bratzler tenderness testing machine are being used in all the studies. During the report period 78 lamb leg samples were tested for palatability. These were representative lambs resulting from the one, two and three breed crosses, and the purebred parent breeds. Tenderness differences were the most striking of all organoleptic characteristics studied. With the exception of one very tough lamb sample, which received a panel rating of 1.6 (very tough) the range was from 6.6 (very tender) to 3.0 (tough). The tenderness average was 4.8 (moderately tender) with a sample standard deviation of 0.91. The variability in tenderness scores was large and suggested a real tenderness problem among the lambs slaughtered. (AH b6-1)

2. Composition.

Ultrasonic measurements of fat and lean depth of 78 lambs from last year were analyzed to study live animal composition. Analysis

revealed that ultrasonics were more effective in determining carcass weights and leg weights than in estimating carcass composition. The estimated depth to the bone (thickness of loin eye) over the last rib of the live lamb was definitely related to the carcass weight and trimmed and untrimmed leg weights when slaughtered weight was held constant. Additional ultrasonic readings are being obtained this year. These consist of readings of fat and lean thickness at one, two and three inches off the midline over the last rib on the right side. (BS 3-34)

Different chemical procedures for evaluating chemical composition of the lamb carcass were compared using 70 lambs. These analyses consisted of ether extract fat of (1) the left rib eye muscle, (2) remaining edible of the rib, (3) ground samples consisting of fat, lean and bone from the right half rib, right leg and remaining cuts of the right side composited as one. A statistical analysis of the data shows that the chemical analysis of the rib sample was significantly correlated with the other method (ground up whole). However, a chemical analysis of the whole leg was the most accurate predictor of a chemical analysis of the total ground side. Chemical analysis of the rib sample was a better measure of carcass composition than physical separation, but the small increase in accuracy does not appear to be justified. (AH b6-1)

3. Carcass Evaluation.

A statistical analysis of the data from 1138 lambs is nearly completed. Relationships among carcass weight, measurements, yields and composition of the rib were analyzed, to determine which of these factors were most important and could be used in determining carcass yield and composition. Carcass weight, body width and either leg circumference or plumpness index were the most important of the 13 carcass factors studied to determine carcass yield. There was no significant increase in accuracy of determining carcass yield by using more than these three factors. Live weight at slaughter was also a reliable estimator of carcass yield. Using an estimating equation developed from the above information it was found that the correlation between the estimated and actual yield of 174 lambs slaughtered during the year was .80. (AH b6-1)

A statistical analysis of data from Dubois, Idaho, shows that the simple correlation between loin eye area and cannon bone circumference was .49, but the apparent association appears to be due to body or carcass weight. The correlation between leg width of the live lamb and that of the carcass was .82. Each of these measurements was relatively highly correlated with other carcass measurements. Carcass leg width was more highly correlated with the other carcass measurements studied than the leg width of the live animal. These results are in agreement with those obtained with the Beltsville lamb data. (AH b6-3)

4. Breeding as it Affects Carcass Quality.

Data on the last group of ram lambs produced from breeding experiments at the U. S. Sheep Laboratory, Dubois, Idaho, and slaughtered at the University of Wyoming have been obtained. Rambouillet lambs averaged lower in both slaughter and carcass grade all three years, with little difference between Targhee and Columbia lambs. Rambouillets had a lower yield of separable fat in the rib than the other two and had larger areas of eye muscle. Differences in composition were more apparent between years than between breeds. In 1959, both yields and composition were decidedly superior to these same factors in either 1960 or 1961. Within years, differences between breeds in both yields and composition were small and require statistical verification. (AH b6-3)

C. Pork

1. Tenderness.

In studies of quality in pork, electrical resistance of muscle tissue is being investigated. Palatability determinations of selected heated pork loins used in this study revealed that rather wide variations were present. Objective measurement of tenderness by the Warner-Bratzler shear and the tenderness press methods on 83 hogs from the reciprocal recurrent selection experiment showed a significant decline in tenderness as the percentage of Landrace blood increased. Panel evaluation of tenderness and juiciness showed significant interactions between breeding groups and sex.

The Slice Tenderness Evaluator (STE), being developed at the Agricultural Research Center in cooperation with A.M.S., was used to determine the tenderness of pork loin roast slices from 61 swine. Highly significant simple and multiple correlations were obtained among STE values for tenderness scores given by the panel. The correlations ranged from .55 to .79 and indicate that this objective tenderness method can be effectively used to measure certain physical characteristics of pork tissue.

Pork loins from 96 pigs slaughtered at 75, 125, 175, 225 and 275 pounds live weight were tested for palatability and other characteristics. Muscle fiber diameter of L. dorsi increased linearly with slaughter weight. No clear-cut differences in palatability were found between pigs slaughtered at these widely-different ages and live weights.

Data on rates of change in electrical resistance obtained on 50 carcasses of reciprocal recurrent selection pigs indicated no significant relationship between electrical resistance changes post mortem and tenderness scores given by the panel. (AH a4-3)

2. Composition.

Analysis on data involving 97 hogs slaughtered at 50-pound weight intervals from 75 to 275 pounds is underway. This experiment was designed to evaluate live animal composition from ultrasonic measures of fat and thickness of eye muscle and to provide basic information concerning growth and fattening. Growth curves of total separable fat and lean indicate that the inflection point for these two carcass components occurs at about 175 pounds. The carcass weight added above 175 pounds is chiefly fat. Correlations between ultrasonic and actual backfat thickness were greatest in hogs of market weight (225 pounds). Multiple correlations obtained among ultrasonic fat thickness, recorded at the shoulder, loin and ham at each of the five weight intervals and total separable fat in pigs slaughtered at 175, 225 and 275 pounds, were highly significant (.73-.92). Ultrasonic fat measures recorded at 75 pounds were effective in predicting backfat thickness in pigs slaughtered at 175 pounds. For pigs slaughtered at 225 and 275 pounds, ultrasonic measures were not effective in predicting backfat thickness until pigs reached 175 pounds.

Research on the use of ultrasonics for evaluating live pigs has indicated that problems previously encountered with multiple fat layers in swine can be overcome by experience in the interpreting of pips as seen on the oscilloscope screen. Seventy-one animals of the high-fat and low-fat swine breeding study were examined ultrasonically for depth of backfat thickness over the ham and depth of lean over the last rib and ham. The thickness of the belly on the pigs at 10, 12, and 14 inches off the midline at the last rib was also recorded. These data are awaiting statistical analysis. The face of the fresh, trimmed ham was traced for fat, bone and muscle areas. These data will be compared with ultrasonic estimates of fat depth and lean depth of the ham measured at locations 2, 4, 6 and 8 inches off the midline over the anterior portion of the right ham. (BS 3-34)

An analysis of data from 42 carcasses at the Oklahoma station indicated that one side could be used for measurement of specific gravity of the carcass and the ham, backfat and length. Removal of the ham from the carcass and subsequent separation into fat, lean and bone was more precise than removal and separation of the middle and shoulder. Carcass length was of no value if backfat was also considered in evaluating the carcass for leanness. The live probe indicated leanness as well ($R^2 = .48$) as backfat thickness ($R^2 = .48$) but not as well as backfat thickness and loin eye area at the 10th rib ($R^2 = .70$). Other indicators of leanness equal to or better than this were: specific gravity of the ham ($R^2 = .69$), specific gravity of the ham and loin eye area ($R^2 = .79$), weight of lean and fat in hams ($R^2 = .92$) and 8 different cross sections spaced from the ham shank to the 2nd

thoracic vertebra (R^2 ranged from .72 for ham shank to .89 for 3rd lumbar vertebra). The indices showed lower relationships to weight of separable lean and thus suggest they were more closely associated with leanness than with protein content of the lean. (AH a1-8)

Live-animal measurements taken at the Wisconsin station on 830 animals at ages ranging from 84 to 154 days showed that measurements at 112 to 154 days may be used with a reasonable degree of reliability for predicting percent lean cuts at a slaughter weight of 205 and 225 pounds. Backfat thickness at the loin and body weight were the best two indicators of carcass merit. (AH a1-10)

At Missouri, 6 live hog measurements were studied to estimate their relative value for predicting percent of live weight that was fat, five primal cuts, and adjusted loin equivalent. The measurements were backfat probe at (1) shoulder, (2) loin, (3) ham, (4) body length, (5) heart girth and (6) flank circumference. These measurements were most useful as indicators of percentage fat ($R^2 = .51$ and $.60$). Significant breed differences in this respect were also observed. (AH a1-6)

Plasma lipid levels were studied on 58 pigs of the fat-lean swine breeding study in the spring of 1962. No pronounced differences in average plasma lipid values were found between the high-fat, low-fat or control lines of pigs. However, pigs of Duroc breeding tended to have higher lipid values (135 mg. percent) than Yorkshire pigs (108 mg. percent). Female pigs within breed and line group appeared to possess lower lipid levels than those recorded for barrows of the same breed and line. Plasma lipid values were not strongly related to the degree of carcass fatness among the animals studied. These studies were conducted, in part, under contract with A. M. S. (AH a4-3)

3. Color.

Research on color in pork as influenced by heredity, sex, age, feeding, and management is being conducted as a PL 480 study with the institute of Animal Physiology and Nutrition, Laboratory for Animal Products, Polish Academy of Science, Warsaw, Poland. Methods and instruments that will be most useful in this study are being investigated. The first report describes trials using a simple photometric method involving a Pulfrich photometer (reflectometer) with Ulbricht ball and a reflectance spectrometer. Forty pork samples were measured with the Pulfrich reflectometer at 7 wavelengths from 460 to 660 m μ . In addition, reflectance values in the visible spectrum of 5-10 m μ intervals within range of 460-660 m μ were determined. With the spectrophotometer method the value of the dominant wavelength, saturation and lightness/brightness/color have been calculated. Values obtained with the Pulfrich reflectometer are being correlated with

those obtained by the spectrometric method. The important factors of color are pigments and water-holding capacity. To determine if these factors are independent or dependent on each other, total pigments, myoglobin, and water-holding capacity were determined on 36 samples of pork. Statistically significant correlations at the one percent level were found between water-holding capacity and total pigment ($r = .44$), and water-holding capacity and myoglobin content ($r = .46$). (E21-AH-2, PL 480)

D. Poultry and Eggs

Preliminary studies are in progress on the colloidal properties of egg yolk. Through microscopic observations of the emulsified material of the egg yolk, it was found that by dilution of the yolk material with neutral salt solutions and careful filtering, it was possible to remove the emulsion. It is planned to determine the lipid composition of the emulsion and the lipid protein interrelationships in the nonemulsified portion of the yolk material by neutral salt precipitation. (AH e4-10)

E. Wool and Fiber

1. Factors Affecting Quality and Value of Wool.

Fleeces from 24 Columbia ewes selected because of their coarse wool at weaning age in 1957 were studied throughout their lifetime at Dubois, Idaho, in informal cooperation with regional project WM-23, Marketing of Western Wools. Quality traits and processing characteristics of the fleeces were studied to determine their desirability as Columbia fleeces and to follow changes in subsequent years. Fleeces on the coarse wool Columbia ewes became coarser from 2 to 3 to 4 years of age. Fibers from the thigh area were coarser than those from the side by 3.0, 3.3, 2.7 and 2.8 microns for each of the 4 ages, respectively. Weight of grease wool, clean wool, and top increased to the third year and then declined slightly for the fourth year of age. Diameter and length of fiber in the top increased over the 4 years of age. A control lot of 24 Columbia ewes with finer fleeces and which had acceptable wool fineness for Columbias at weaning age were also studied over 4 years of age. The control fleeces also became coarser from one to 4 years but slightly less than the coarse fleeces.

Investigation of the relationship between quality traits and the economic returns from wool at Dubois, Idaho, was continued in 1961. The 64/70's quality fleeces were classed into three lots and 60/62's into two lots according to length of staple. One lot each of 56/58's, 50/54's, and 46/48's quality fleeces was studied. Average fiber diameter, staple length, clean fiber content and vegetable material were determined for each lot. The fleeces classed as 64/70's average French and the 60/62's French made lots too small to be useful for

price comparisons. Two variable grade lots (control lots) were made up, tested for quality traits and clean fiber content and sold as original bag wool. Graded lines sold for 45.0 to 50.5 cents per grease pound. Wools of uniform quality sold for 3.25 cents more per pound than variable grade lines and fine staple wool sold for 3.75 cents more than fine French wool. Crutchings and shearing pieces from the fleeces making up the graded lines were mill scoured and yielded a clean fiber content of 41.2%. This wool sold for 31.4 cents per pound on grease basis.

To determine the importance of the relationship of lamb birthcoat to other fleece and body traits, birthcoats of 2534 Rambouillet, Targhee and Columbia lambs were scored (1 to 5) for the amount of hair-like fibers and for the amount of wool fibers present. Correlations were computed (holding constant sex, breed, type of birth and rearing, age of dam and days of age) between hair and wool scores and birth weight, weaning traits (staple length, bodyweight and belly wool) and yearling traits (staple length, bodyweight, belly wool, grease fleece weight, clean fleece weight, side and thigh grades). In addition, correlations were computed between the birthcoat scores and fleece grade, fleece value, uniformity of length and grade, and components of the sorted fleece (main sort, other sorts and off-sorts). Correlations (-.14 to 0.14) between hair score at birth and the other wool and body traits studied were low and unimportant, although, some were statistically significant. Correlations (-.21 to 0.24) between wool score at birth and the other wool and body traits studied were slightly higher in most instances than those between hair score at birth and the other wool and body traits. These results indicate that the amount of hair-like fibers and wool fibers in the birthcoat as determined by the scoring technique used has little or no relationship to future bodyweight or to the quality or quantity of wool produced. (AH b5-2)

2. Measuring Method to Evaluate Wool.

At Beltsville, Maryland, a crimp scale has been designed to facilitate the measurement and recording of width/depth ratio and number of crimps per inch. Interlaboratory tests are now underway to test the feasibility of using the scale to measure crimp in grease staples. It is necessary to determine if the scale is practical and whether laboratories can classify crimp from various samples of wool by use of this scale. If the scale and method seem feasible, additional testing for corroboration will be conducted.

A method was developed for measuring fiber length with the Wool Industries Research Association machine. Individual fiber length was measured in four wool grades by ruler and by the WIRA method. Two operators measured unstretched and stretched length by ruler and

duplicate lengths by WIRA. Each operator pulled and measured two fibers from each of two levels ($1/3$ and $2/3$ from the base) of each of 25 locks for each grade and also measured those pulled by the other operator. Analyses of variance with variance component estimates, expected standard errors, and certain means, were computed separately for each grade. Although variance component estimates were generally larger for stretched than for unstretched measurements there was little difference between the methods expressed as percent of the total or as percent standard error of the mean. Average WIRA measurements, their variance component estimates, and standard errors of the means agreed more closely with stretched than with unstretched ruler measurements for all grades. Standard errors as a percent of the mean were larger for the WIRA than for either ruler measurement. Differences among pulling operators, levels and their interactions were generally small and insignificant. Measuring operators differed significantly and interacted with the ruler vs. WIRA classification. Their differences were larger with the ruler but still existed with the WIRA. WIRA measurements recorded to 0.5 cm. seem to contain considerable rounding error. A method of measuring fiber length with the WIRA developed from this study involves two operators, each pulling and measuring 8 fibers from one level of each of 50 representative locks from a lot or fleece.

Research is being conducted on the possibility of adapting the Coulter Counter for use in measuring the fineness and variability of wool fibers. The instrument is an electronic particle-size counter. Studies were conducted in cooperation with personnel of the Market Quality Research Division, AMS. Satisfactory results, comparable to those obtained by the standard method of the American Society for Testing Materials, have been obtained on certain wool top samples with this instrument. Problems were encountered with changes in temperature of the electrolyte affecting results through changes in the voltage drop across the aperture, improper stirring of the solution and fibers, and blockage of the aperture tube. A more refined and efficient model of the Coulter Counter is now being tested at Beltsville.

The standard method of determining fiber diameter and distribution is time-consuming and tedious, since the fibers lie at various angles on the slide, making it necessary to rotate the wedge scale considerably in order to measure each fiber properly. To develop a means of aligning the fibers for greater ease and speed of measurement, an electrostatic fiber alignment device was produced by the Special Instruments Laboratory, Knoxville, Tennessee, working with the U. S. D. A., Sheep and Fur Animal Research Branch, Beltsville, Maryland.

In order to use the device, the operator prepared a slide in accordance with standard specifications of the American Society for Testing Materials up to the mounting of the fibers. The fiber pieces are dispersed in an immersion oil and the cover slip is placed in position.

The slide is then placed in the slide holder which is inserted in the device. The cover plate is placed on the device and the fibers begin to align immediately. Alignment is completed and the medium sets sufficiently while a second slide is being prepared. Measurements are then made and recorded as outlined in the ASTM standard. Fiber dispersion is considerably improved with few, if any, intersecting fibers, when the alignment device is used with this immersion oil. For visual measurement by the microprojection method, alignment of the wool fibers lessens the number of movements of the wedge scale in determining the fiber diameter, thereby increasing the operator's speed in measurement.

Gamma-ray measurements were made of wool in cooperation with the Agricultural Marketing Service at Beltsville, Maryland, to study the relationship of gamma-ray emission of grease wool to the foreign matter content. The potassium contents of the grease wool fleeces were estimated from the K^{40} gamma-rays and were found to vary widely. Since the suint (dried perspiration) is high in potassium, variations in grease wool potassium may reflect variations in suint content which are related to individual fluctuations in the amount and type of feed consumed. Scouring removed the bulk of the potassium present in grease wool. The variability of the potassium level found in scoured wool, ranging from 0.15 to 0.46%, suggests that potassium might be present in impurities which were not removed in the scouring procedure used in this study. Cs^{137} values for scoured wool were usually much lower than for grease wool, ranging from 1.6 to 4.4 gamma-ray emissions per second per pound. In general, Cs^{137} levels in scoured wool tended to reflect the levels present before scouring. The estimated potassium content and Cs^{137} gamma-ray emission rate did not appear to be closely related to the total content of impurities present in the grease wool fleeces studied. Further work involving fractionation to determine the actual suint content is needed to determine if K^{40} gamma-ray measurements can provide a useful estimate of total suint content. The gamma-ray measurement technique for estimating potassium content of whole fleeces may also be very useful in potassium balance studies. (AH b5-3)

3. Effect of Pregnancy and Lactation on Wool Production.

The problem of selecting mature ewes on the basis of wool production is nearly always confounded with lamb production. That is, those ewes that wean the most pounds of lamb probably produce the least amount of wool. This problem dealing with the effect of pregnancy and lactation on wool production has been investigated at the Fort Wingate Station. The least squares analysis included grease fleece weights for five years, 1955-1959, from 2241 ewes of all ages, from 7 breeding groups and included all 18 possible pregnancy-lactation groups. The study shows that ewes which gave birth to twins, weaned

twins and then became pregnant with twins again produced fleeces which averaged only 6.47 pounds. Ewes which were dry during the summer and then failed to become pregnant sheared an average of 8.00 pounds of wool. Ewes that weaned a lamb or lambs but were dry the following fall and winter sheared 7.41 pounds of wool compared to 7.80 pounds of wool for ewes that were dry during the summer but became pregnant during the fall. This probably indicates that lactation has a greater effect on wool production than does pregnancy. (AH b5-6)

4. Relation of Fleece Traits to Processing Characteristics.

Preliminary results have been obtained at Beltsville on studies of the relationship of carding and combing to inherent differences in wool. This study was designed to determine whether observed variations between grades of wool are due to inherent differences in the wool, to differences in machinery settings normally used in the processing of these different grades of wool or to a combination of these factors. Such information is essential in interpreting data obtained from carding and combing individual fleeces. The data which have been analyzed include weights and yields of card sliver, top and noils. Three separate analyses gave the following information: In analysis 1, fine wool and 1/2 blood wool carded with medium settings on the carding machine showed no statistical difference; with fine settings there was a highly significant difference in card yield. In analysis 2, 1/2 blood, 3/8 blood and 1/4 blood wools showed no differences with coarse settings but were significantly different with medium settings; and in analysis 3, 1/2 blood wool showed no differences with medium or coarse settings, but highly significant differences with fine settings. More detailed analysis of these data is necessary since the preliminary analyses indicate that significant differences in card yields are correlated with carding machine settings. From the same three analyses, highly significant differences were obtained for all grades of wool top and noil yields when the gauge setting which controls noilage was altered. Therefore, the amount of noils is more directly controlled by setting of the comb than by grade of wool.

Fourteen grade-breed lots from Dubois, Idaho, each containing 15 mature ewe fleeces visually grading the same, were studied to investigate further relationships among quality traits of grease wool to processing characteristics, yield and quality of top. Each grade-breed lot was sampled in the grease, scoured at the University of Wyoming Wool Laboratory and processed into top at Philadelphia Textile Institute. Data from the first year indicate that as the fiber diameter of grease wool increases within a breed, staple length increases, number of crimps per inch decreases, grease fleece weight increases, clean yield becomes higher, top yield per pound of clean wool increases, and variability of both fiber length and diameter in the top becomes greater. Columbia wool was slightly longer, had fewer crimps per inch, and was coarser than Targhee wool of the same visual grade.

Targhee wool was longer, had fewer crimps per inch and was coarser than Rambouillet wool of the same visual grade. (AH b5-7)

F. Humane Slaughter

1. Cornell University.

Research is in progress at Cornell University to determine the physiological affect of immobilization with different percentages of carbon dioxide mixed with air or oxygen and to study the effects of carbon dioxide upon bleeding and carcass quality. Blood levels of 80 volume percent CO₂, or more, were required to effect rapid immobilization. This level was reached with 68% CO₂ combined with air or oxygen. Added oxygen will prolong the time an animal can maintain heart action. However, even at oxygen concentrations greater than atmospheric (25% vs. 21% in air) sheep cannot be maintained under 75% CO₂ for more than 15 to 20 minutes. Electroencephalograms from sheep and pigs showed similar changes following treatment with cyclopropane, nebutal or CO₂. However, this could not be considered conclusive proof of the anesthetic action of CO₂ without measurement of cerebrospinal fluid pressure or intracranial pressure, which may have been influencing factors. Muscle tissue from animals immobilized with CO₂ and air was darker than tissue from animals immobilized with CO₂ and oxygen, with the tissue color persisting for several days after slaughter. It may be desirable to have more O₂ in a CO₂ immobilization chamber than that supplied by air because of meat color and danger of killing animals. However, blood pressure is elevated with added oxygen and more hemorrhages were observed. (AH j1-1)

2. Beltsville, Maryland.

Investigations were continued into the effects of different methods of immobilization upon meat quality, and into the changes in skull development with advancing age. Seventy two swine were immobilized, half by electrical and half by mechanical means. No differences that could be attributed to the method of immobilization were found in the pH of the gracilis muscle or blood, blood glucose, blood creatinine, muscle glycogen, muscle lactic acid or observations on lungs, viscera and hams.

Studies were made on 28 sheep immobilized by captive bolt stunners to determine the effects upon arterial and venous blood pressure, heart rate and respiration. An electronic recording system was used. It was found that arterial blood increased to a peak within 15-25 seconds. Using a mean arterial blood pressure of 30 mm of mercury as an arbitrary point below which blood will not be pumped from the body by the heart it was found this point was reached in 3 minutes and 18 seconds to 7 minutes and 40 seconds. Pressure in the jugular vein also rose very high at impact, then gradually diminished. Heart rate increased at

impact, reaching a peak in 15 to 25 seconds then gradually decreasing. Respiration ceased at time of impact where there was a solid blow to the cerebrum. At a period of from 6 to 25 seconds after impact there was a series of muscle spasms accompanied by a rapid irregular ventilation of the lungs. These spasms lasted from two to ten seconds, decreasing in duration. (AH j1-2)

3. University of Minnesota.

Investigation into the physiological effects of electrical immobilization and into the evaluation of pain are being conducted at the University of Minnesota. One field of study was the comparative effects of trans-occipital or trans-parietal stunning to that of the cranid-thorax or cranio-gluteal method. This latter procedure had been adapted by certain packing plants because of the absence of post-immobilization convulsions. Upon attempting to duplicate the conditions of the packing plants it was found that sheep stunned in the cranio-thorax or cranio-gluteal areas were instantly electrocuted. The mode of action of this type of stunning appears to be an arrest of the action of the nervous impulses traveling to the S-A node, after which some ectopic focus in the ventricles tries to maintain activity until advanced hypoxia prevents further action.

Studies were initiated into the complex problem of determining whether or not the animal feels pain upon being immobilized electrically. Using psychological and electrophysiological techniques, a method was developed to condition an animal to respond under certain stimulus. A conditional response was developed in the somatic (leg movement) and the autonomic (respiration, blood pressures and heart rate) and the parameters measured by the electroencephalogram. The results indicate that a shock to the head of 10 M.A. magnitude is painful to the animal and that shocks of greater magnitude, such as those applied during stunning, should also be painful unless the animal is rendered unconscious by the activity of such a current. In conditioned animals somatic, autonomic and electroencephalographic responses were developed. This indicates that the stimulus used was painful to the animal and that the animal was not rendered unconscious by a current magnitude of less than 100 M.A. The conditioned somatic response was, however, erratic in its development under these conditions, which indicates that a degree of unconsciousness may have been developed but not to the extent that this stimulus would be acceptable for humane slaughter. In the second group of animals in which no condition responses were developed, indicates that a current of greater than 100 M.A. is sufficient to render the animal unconscious. In the third group of animals conditioned responses were developed in all measured parameters. This indicates that not only does a current of less than 100 M.A. magnitude not produce unconsciousness but that a retrograde amnesia does not develop as a result of this current. In a fourth group in which conditioned responses were not developed in any parameter, a current

of greater than 100 M.A. magnitude not only results in a state of unconsciousness but also results in a retrograde amnesia of at least one minute duration.

In a study of pain pathways there is an indication that the "pain" pathways in sheep are limited to the ventro lateral quadrant of the spinal cord. The course of the fibers up the cord appear to exhibit some diffuseness, i.e., crossing over initially to the contralateral side and crossing back ipsilaterally after ascending 4-5 segments. This diffuseness, however, does not seem to equal that found in the pig by previous studies, but seems to be similar to that in the cat as illustrated by other investigators. (AH j1-3)

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None

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Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Incl. in	
			Summary of Progress	Area & Sub-Subheading
AH a1	Swine Breeding Investigations	-	Yes	15
AH a1-3	Development of inbred lines within Duroc, Chester White and Landroc swine and various crosses	Lafayette and Wanatah, Ind.	Yes	15-A-5 15-B-4 16-B-2
AH a1-4	Improvement of swine through breeding	Ames & Ankeny, Iowa	Yes	15-A-1 15-B-1,3,4
AH a1-6	Effectiveness of selection for swine carcass quality based on backfat thickness	Columbia, Mo.	Yes	15-A-1 15-B-1 16-A-2 16-B-1 20-C-2
AH a1-7	Breeding for improvement of economic traits in swine - purebred and crossbred foundation stocks	North Platte & Lincoln, Nebr.	Yes	15-A-4 15-B-4 16-A-1
AH a1-8	Selection for combining ability of three lines of swine	Stillwater & Fort Reno, Okla.	Yes	15-A-1,3 15-B-2,3,4 20-C-2
AH a1-9	Inbreeding, line-crossing and selection within and between the Hampshire, Duroc and Yorkshire breeds of swine	Brookings, Eureka & Centerville, S. Dak.	Yes	15-B-1,3,4
AH a1-10	Methods of breeding and selection in swine	Madison, Wis.	Yes	15-A-1 15-B-2 20-C-2
AH a1-11	Recurrent reciprocal selection for high specific combining ability in crosses between Yorkshire and Mont. No. 1 swine	Miles City, Mont.	Yes	15-A-2 15-B-2
AH a1-12	Selection for high and low degrees of fatness in swine	Beltsville, Md.	Yes	15-A-4 15-B-1
AH a1-13	Reciprocal recurrent selection for general and specific combining ability in two strains of swine	Beltsville, Md.	Yes	15-A-2 15-B-2
AH a1-14	Use of rapid inbreeding with selection in evaluating and utilizing potential sources of superior germ plasm	East Lansing, Mich.	Yes	15-A-1 15-A-5 15-B-3
AH a1-15**	Swine metabolism investigations	Beltsville, Md.	No	
AH a1-16	Effectiveness of selection in purebred and crossbred foundation stocks	Urbana, Ill.	No	
AH a1-17	Selection, inbreeding and crossing for swine improvement	St. Paul, Crookston, Duluth, Grand Rapids, Morris, Rosemount & Waseca, Minn.	Yes	15-A-1,5 15-B-3,4
AH a2	Swine Management Investigations		Yes	17
AH a2-3	Evaluation of new or improved types of hog rearing	Beltsville, Md.	Yes	17-E-1,2
AH a2-4	Evaluation of pasture and harvested forage in swine production	Beltsville, Md.	Yes	17-A-1 17-C-1
AH a3	Swine Feeding and Nutrition Investigations		Yes	17
AH a3-11	Effect of vitamin level during gestation on reducing death losses in young pigs	Beltsville, Md.	Yes	17-D-2
AH a3-12	Trace mineral requirements and biochemical pathways relating to mineral utilization by swine	Beltsville, Md.	Yes	17-D-1
AH a3-14	The interrelations of nutritional and metabolic status with susceptibility of the baby pig to specific infectious diseases	E. Lansing, Mich.	Yes	17-D-3
AH a3-15	The relation of diet to mineral balance & body composition in young pigs as modified under stress imposed by enteric infections	Urbana, Ill.	Yes	17-D-3

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Incl. in	
			Summary of Progress	Area & Sub Subheading
AH a3	Swine Feeding and Nutrition Investigations (continued)			
AH a3-16	Improving the safety and use of cottonseed meal as a swine feed	Beltsville, Md.	Yes	17-B-1
AH a3-17	Comparative effects of high fiber feedstuffs in the production of lean pork carcasses	E. Lansing, Mich.	Yes	17-A-1 17-C-1
AH a4	Pork Studies		Yes	20-C
AH a4-3	Meat characteristics of carcasses of pork developed through breeding nutrition and management	Beltsville, Md.	Yes	20-C-1, 2
	** Initiated during report year			

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Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Incl. in	
			Summary of Progress	Area & Sub- Subheading
AH b1	Sheep breeding investigations			12 13-A
AH b1-1	Selective mating and breed comparisons of sheep for farming regions	Beltsville, Md.	Yes	12-B-1
AH b1-2	Lamb and wool production from crossbred sheep from the Hampshire, Shropshire and Southdown breeds	Beltsville, Md.	Yes	12-B-1
AH b1-3	Development of a strain of sheep for maximum production of lambs and wool under farm conditions	Beltsville, Md. Middlebury, Vt.	Yes	12-B-2
AH b1-4	Selecting and crossbreeding of Merino sheep for increased productivity	Beltsville, Md.	Yes	12-B-1
AH b1-5	Investigations of systems of breeding for improvement of range sheep	Dubois, Idaho	Yes	12-B-3
AH b1-6	Investigations of traits for use in breeding and selection of range sheep	Dubois, Idaho	Yes	12-A-1,2,3
AH b1-7	Studies in physiology of reproduction of range sheep	Dubois, Idaho Logan, Utah	Yes	13-A-1,2, 3,4,5,6
AH b1-8	Occurrence of estrus in sheep as related to reproductive performance	Beltsville, Md.	No	---
AH b1-10	Improvement of Navajo sheep by line breeding and selection within the Navajo strain	Fort Wingate, N. Mex.	Yes	12-B-5
AH b1-11	Improvement of fine wool sheep under Southwest conditions	Fort Wingate, N. Mex.	Yes	12-B-5
AH b1-12	Improvement of coarse wool sheep for the production of wool suitable for Navajo hand weaving	Fort Wingate, N. Mex.	Yes	12-B-5
AH b1-13	Influences of breeding on efficiency of gains in range sheep	Dubois, Idaho	Yes	12-A-4
AH b1-14	Testing of inbred lines of sheep through top crossing	Dubois, Idaho Bozeman, Mont.	Yes	12-A-1 12-B-4
AH b1-15	Investigations of blood group relationships in sheep	Dubois, Idaho Davis, Calif.	Yes	12-A-5
AH b1-16	Improvement of commercial range sheep through breeding and selection	LaSal & Logan, Utah, Ft. Collins, Colo., Beltsville, Md.	Yes	12-B-5
AH b1-17**	Development by selective breeding of a strain of sheep which will reproduce more often than once per year and without seasonal restriction	Beltsville, Md.	Yes	12-B-2
AH b2	Sheep feeding investigations		Yes	14-A, B
AH b2-1	The cause and prevention of urinary calculi in fattening beef cattle and sheep	College Station Amarillo, Texas	Yes	4-A-3 14-A-1
AH b2-5	Factors in the utilization of pelleted feeds by sheep and other ruminants	Beltsville, Md.	Yes	14-A-2 14-A-3
AH b2-6	Investigations of physiological reactions of sheep and other ruminants in relation to metabolic disorders	Beltsville & College Park, Md. Ithaca, N. Y.	Yes	14-A-1
AH b2-7	Investigations on the utilization of forage by sheep	Beltsville, Md. Newark, Del.	Yes	14-B
AH b2-8	Investigations on the nutritive value of new or improved forages	Beltsville, Md.	Yes	14-B
AH b3	Sheep management investigations		Yes	13-B,14-A, C, D
AH b3-1	Investigations of sheep grazing management on ranges of the Intermountain region	Dubois, Idaho	Yes	14-C-1
AH b3-4	The response of Targhee sheep to different environments	Hawaii, Dubois, Idaho, Beltsville, Md., Ft. Wingate, N. Mex., Spooner, Wis.	Yes	13-B-1
AH b3-5	The effect of shearing, light and season on rate of wool growth	Beltsville, Md., Albany, Calif.	Yes	13-B-3

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Incl. in	
			Summary of Progress	Area & Sub- Subheading
AH b3	Sheep management investigations (continued)			
AH b3-6*	Investigations of the cause of lamb mortality and development of methods of reducing it	Beltsville, Md.	Yes	14-D-1
AH b3-7	Methods of producing milk fat "spring" lambs	Ft. Reno, Okla.	Yes	14-A-2 14-D-2
AH b3-8	Influence of environment at different geographic locations on fleece and body traits of sheep	Tifton, Ga., Dubois, Idaho, Beltsville, Md. University Park, N. Mex.	Yes	13-B-2
AH b3-9	Investigation of nutrition and management of range sheep	Dubois, Idaho	Yes	14-A-2 14-B 14-C-1 4-D-3
AH b3-10	Comparative productivity of pastures grazed by beef cattle alone, sheep alone and by the two species in combination	Beltsville, Md.	Yes	14-C-2
AH b3-11**	Influence of management practices on internal parasitism of lambs	Beltsville, Md.	Yes	14-A-2 14-C-3
AH b4	Goat nutrition investigations		Yes	1
AH b4-3**	Investigation of dairy goat production	College Park & Beltsville, Md.	Yes	1-C-4
AH b5	Investigations of wool and other animal fibers		Yes	13-C,20-E
AH b5-1	Growth and development of the skin, fibers and accessory follicular structures in goats	McGregor, Texas & Beltsville, Md.	Yes	13-C,1,2,3
AH b5-2	Factors affecting the quality and value of wool	Dubois, Idaho & Beltsville, Md.	Yes	20-E-1
AH b5-3	Evaluation of wool from farm sheep for breeding, nutrition and management studies	Beltsville, Md.	Yes	20-E-2
AH b5-5	Influence of age and season on the skin and follicular structures associated with shedding in Angora goats	McGregor, Texas & Beltsville, Md.	Yes	13-C-4
AH b5-6	Investigations of wool for the improvement of Navajo, Navajo crossbred, Targhee and Targhee crossbred sheep under Southwest range conditions	Fort Wingate, N. Mex.	Yes	20-E-3
AH b5-7	Relation of fleece traits to processing characteristics, yield, and quality of card sliver and top	Dubois, Idaho,& Beltsville, Md.	Yes	20-E-4
AH b6	Mutton, lamb and chevon studies		Yes	20-B
AH b6-1	Meat characteristics of carcasses of lambs representing certain breeds and crosses	Beltsville, Md.	Yes	20-B-1,2,3
AH b6-3(C)	Evaluation of meat characteristics of lamb carcasses and their relationship to live animal characteristics for genetic studies	Dubois, Idaho Laramie, Wyo.	Yes	20-B-3,4
	* Discontinued during report year. ** Initiated during report year.			
AH c3**	Horse and jackstock investigations ** Initiated during report year.	Beltsville, Md.	Yes	19

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Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Incl. in	
			Summary of Progress	Area & Sub-Subheading
AH dl	Beef and dual-purpose cattle breeding investigations		Yes	2, 3
AH dl-1	Breed crossing for increased production in beef cattle	Miles City, Mont.	Yes	2-C-1
AH dl-2	Development of superior lines of beef cattle	Miles City, Mont.	Yes	2-B 2-C-3
AH dl-3	The development of more efficient beef cattle for Georgia through the use of selection, progeny testing, inbreeding and crossbreeding	Tifton, Ga. Reedsville, Ga.	Yes	2-C-1
AH dl-4	The improvement of beef cattle for Virginia through breeding methods	Front Royal & Blacksburg, Va.	Yes	2-B 2-C-2
AH dl-5	Selection of cattle adapted to beef production in Southeastern United States	Brooksville, Fla.	No	
AH dl-6	Development of pure and crossbred types of cattle for Southeastern United States and the Gulfcoast region	Jeanerette, La.	Yes	2-B,3-A-9
AH dl-7	Heterosis from crosses among British breeds of beef cattle	Blacksburg, Va. Steele's Tavern, Va.	Yes	2-C-1
AH dl-8	Evaluation of performance records in beef cattle	Fayetteville, Ark.	Yes	2-B
AH dl-9	The improvement of producing ability of beef cattle	Knoxville, Tenn.	Yes	2-A-1, 2-B
AH dl-10	The improvement of beef cattle through breeding methods	Ames, Iowa	Yes	2-B
AH dl-12	Effectiveness of selection for productive efficiency and carcass quality and the importance of heterosis in beef cattle	Ft. Robinson & Lincoln, Nebr.	Yes	2-A-1, 2 2-B 2-C-1 3-A-5
AH dl-13	The effectiveness of inbreeding and selection in the improvement of performance of beef cattle	Brookings, S. Dak.	Yes	2-B 2-C-3
AH dl-14	Breeding and selection of beef for the Southwest	Tucson & San Carlos, Ariz.	Yes	2-C-3
AH dl-16	A study of selection, inbreeding, and crossing of inbred lines within the Hereford breed	Ft. Collins & Ft. Lewis, Colo.	Yes	2-C-2
AH dl-17	Recurrent selection and record of performance selection in open and closed beef cattle herds	Bozeman & Havre, Mont.	Yes	2-C-3
AH dl-18	Breeding beef cattle for Southwestern ranges	St. College, N. Mex.	Yes	2-A-1
AH dl-19	The improvement of beef cattle through breeding methods using basic physiological differences in rate and efficiency of gains and carcass evaluation	Corvallis, Ore.	Yes	2-A-1,3 2-C-2
AH dl-20	The development of breeding techniques and selection criteria for improvement of economically important characteristics in Hereford and Shorthorn cattle	Logan, Utah	Yes	2-B 2-C-2
AH dl-22	The improvement of production and adaptation of beef cattle within purebreeds and certain of their crosses through breeding methods	College Station & McGregor, Texas	Yes	2-A-1 2-B
AH dl-23	Genetic and environmental interactions for performance and carcass traits in beef cattle	Raleigh, Plymouth, Laurel Springs & Butner, N. C.	Yes	2-A-3
AH dl-25	Improvement of beef cattle through the application of breeding methods: I. Criteria for improving effectiveness of selection. II. Head form studies, and III. Immunogenetics in beef cattle	Laramie & Gillette, Wyo.	Yes	2-B
AH dl-27	Relationships of beef and dairy characters in Milking Shorthorn cattle	Rosemont & St. Paul, Minn.	Yes	2-A-2
AH dl-28	A study to determine the breeding worth of inbred and outbred bulls from various sources	St. College & Prairie, Miss.	Yes	2-A-2 2-B
AH dl-29	Improvement of beef cattle of Alabama through breeding methods	Auburn, Ala.	Yes	2-B

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Incl. in	
			Summary of Progress	Area & Sub-Subheading
AH d1	Beef and dual-purpose cattle breeding investigations (continued)			
AH d1-30	Improvement of reproductive performance in beef cattle	Jeanerette, La. and Beltsville, Md.	Yes	3-A-9, 10
AH d1-31	Effectiveness of selection for productive efficiency and carcass merit and the development of techniques for the identification of dwarfism carriers in beef cattle	El Reno & Stillwater, Okla.	Yes	2-A-1 2-C
AH d1-32	Genetic-environmental influences on production and carcass traits in beef cattle	Beltsville, Md.	Yes	2-A-3
AH d1-33	A study of reproductive physiology in range cattle	Miles City, Mont.	Yes	3-A-7
AH d1-34	Genetics of dwarfism in beef cattle	Gainesville, Fla.	Yes	2-A-1
AH d1-35*	A study of dwarfism in beef cattle	Blacksburg, Va.	No	
AH d1-36	The effect of genetic-environmental interactions on selection responses in beef cattle	Reno, Nevada, & Nevada branch stations	Yes	2-A-3
AH d1-37	Improvement of reproductive performance in beef cattle	Ft. Robinson, Nebr.	Yes	3-A-2,3,4, 5,6
AH d1-38	A study on genetic influences on growth, conformation (C) and carcass characteristics of beef cattle	Brookings, S. Dak.	Yes	2-A-2
AH d1-39	Biological and genetic analyses of normal and mutant stocks in beef cattle with special emphasis on dwarfism	Davis, Calif.	Yes	2-A-1
AH d1-40	Breeding experiments to investigate the nature of genetic improvement in beef cattle productivity with special emphasis on the performance of inbred lines and their crosses	Davis, Calif.	No	
AH d2	Beef and dual-purpose nutrition investigations		Yes	3,4
AH d2-3	Evaluation of feeds and forages for beef production in the Coastal Plains region	Tifton, Ga.	Yes	4-C-1
AH d2-8	Techniques for evaluation of feed intake, digestibility, and utilization of forage by grazing beef cattle and other livestock	Beltsville, Md. Raleigh, N. C.	Yes	4-A-1,7,8
AH d2-10	Cause and prevention of cattle losses on wheat and other pastures with special reference to grass tetany	College Station, Texas	No	
AH d2-11	The effect of interrupted growth on the efficiency of beef production	Beltsville, Md.	Yes	4-E-1
AH d2-12	Growth, development, and reproductive performance of heifers and cows under different winter feeding treatments	Fort Reno, Okla.	Yes	4-D-1
AH d2-13	Cause and prevention of acute bloat in ruminants	Beltsville, Md.	Yes	4-A-2
AH d2-14	Nutritive value of feeds and forages as influenced by lignin, cellulose, and other feed components	Beltsville, Md.	Yes	4-A-1,6
AH d2-21	Management and feeding practices affecting the gains of beef cattle on the range and in the feedlot	Ft. Robinson, Nebr.	Yes	4-B-3
AH d2-22	Determination of the relation between protein and energy deficiencies and reproductive ability of beef cattle	Beltsville, Md.	Yes	3-A-1
AH d2-24	The effect of ruminal microorganisms on plant saponins and related compounds	Beltsville, Md.	Yes	4-A-5
AH d2-26	Studies on the nutritional relationships between the ruminal protozoa and bacteria and their contribution to digestion in cattle and other ruminants	Beltsville, Md.	Yes	4-A-5
AH d2-28	The relation of physical form and roughage content to the feeding value of beef cattle rations	Beltsville, Md. Front Royal, Va. Ft. Reno, Okla.	Yes	4-B-1

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			Summary of Progress	Area & Sub- Subheading
AH d2	Beef and dual-purpose nutrition investigations (continued)			
AH d2-30	Influence of harvesting factors on the nutritive value of corn and other grains	Beltsville, Md.	Yes	4-C-2
AH d2-31 (b2-1)	The cause and prevention of urinary calculi in fattening beef cattle and sheep	College Station, Texas	Yes	4-A-3 14-A-1
AH d2- 32**	Investigations of residues of new pesticides when ingested by beef cattle	Beltsville, Md., Tifton, Ga.	Yes	4-A-4
AH d2- 33**	Comparative feeding value of new and stored shelled corn for beef cattle	Wooster, Ohio	Yes	4-B-2
AH d2- 34**	Evaluation of pastures and forages in the Gulf Coast area in terms of reproductive performance by beef cattle	Jeanerette, La.	Yes	3-A-8
AH d3	Beef and dual-purpose management investigations		Yes	4, 5, 20
AH d3-1	Sustained beef cattle production and maintenance of range quality in the Northern Great Plains	Miles City, Mont.	No	
AH d3-2	Management of pastures and cattle for beef production	Brooksville, Fla.	Yes	4-E-2
AH d3-3	Improving herd management on forest range	Alapaha, Ga.	Yes	4-D-2
AH d3-4	Integration of livestock and timber production on intensively managed pastures	Alapaha, Ga.	Yes	4-D-2
AH d3-6	The comparisons of the production of beef from beef, dual-purpose, and dairy steers	Beltsville, Md.	Yes	4-E-3 5-A-7 20-A-3
AH d4	Beef and veal studies		Yes	20
AH d4-4	Histological characteristics of muscle tissue of beef developed through breeding, nutrition and management	Beltsville, Md.	Yes	20-A-1
AH d4-5	Characteristics of the eating quality of meat in relation to breeding and other production factors in beef	College Station, Texas	Yes	20-A-1
AH d4-6	Biochemical characteristics of beef tissue as affected by production of cattle	Beltsville, Md.	Yes	20-A-1
AH d4-7	Meat characteristics of carcasses of beef developed through breeding, nutrition and management	Beltsville, Md.	Yes	20-A-3
AH d4-8 (C)	Production factors that influence beef tenderness and the development and evaluation of suitable methods for appraising tenderness	Lincoln, Nebr.	No	
	* Discontinued during report year			
	** Initiated during report year			

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Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Incl. in	
			Summary of Progress	Area & Sub-Subheading
AH e1	Poultry breeding investigations		Yes	8
AH e1-1*	The development of a strain of single comb White Leghorns resistant to heat	Beltsville, Md.	Yes	8-A-4
AH e1-2*	Crossing of inbred lines within the same breed of chickens	Glendale, Ariz.	No	
AH e1-4*	Crossbreeding and incrossbreeding chickens of widely divergent origin and type	Beltsville, Md.	No	
AH e1-5*	The inheritance and improvement of meat quality in poultry	Beltsville, Md.	No	
AH e1-30*	Combining reproductive characteristics with superior egg quality in chickens	Beltsville, Md.	Yes	8-A-3
AH e1-35(C)*	Improving poultry through improved performance testing	Beltsville, Md.	Yes	8-B-1
AH e1-41*	Maintenance of control populations for estimating progress in poultry breeding	Beltsville, Md.	No	
AH e1-42	Genetic and physiological studies of the red blood cell antigens in the domestic fowl	Beltsville, Md.	No	
AH e1-43(C)	Evaluation of breeding systems for chickens	Lafayette, Ind. & 11 North Cent. Expt. Stations	Yes	8-A-3,4,5 8-C-1,2
AH e1-44	Development and evaluation of breeding techniques in chickens	Athens, Ga. & 14 Southern State Expt. Stations	Yes	8-A-1,2,4,5 8-C-2
AH e1-45	Genetic and physiologic bases for poultry improvement	Twelve North-eastern State Expt. Stations	Yes	8-A-5 8-C-1,2
AH e1-46	Genetic and environmental factors affecting reproduction in turkeys	Six Western State Expt. Stations	Yes	8-A-4
AH e1-47**	Avian reproduction under subcircadian periodicities	Beltsville, Md.	No	
AH e1-48**	Genetic aspects of the ability of chickens to utilize amino acids	Beltsville, Md.	No	
AH e2	Poultry nutrition investigations		Yes	10
AH e2-13	Fat metabolism in poultry	Beltsville, Md.	Yes	10-A-1 10-B-1
AH e2-14	Feeding systems in poultry	Beltsville, Md.	Yes	9-D-3
AH e2-15	Effect of high air temperatures on optimum levels of nutrient in diets for chickens	Glendale, Ariz.	Yes	10-B-2
AH e2-16	Protein and amino acid requirements of chickens and turkeys	Beltsville, Md.	Yes	10-A-2 10-C-2
AH e2-17	Cottonseed meal in chicken diets	Glendale, Ariz.	Yes	10-C-1
AH e2-18	Mineral requirements of poultry	Beltsville, Md.	Yes	10-A-3
AH e3	Poultry physiology investigations		Yes	9
AH e3-10*	Estrogen-gonadotrophin relationships in the fowl	Beltsville, Md.	No	
AH e3-11(C)*	Anterior pituitary requirements for maintenance of complete ovarian function in the hypophysectomized hen	Urbana, Ill.	No	
AH e3-13*	Physiological responses of chickens to environmental variables	Beltsville, Md.	Yes	9-B-2
AH e3-14*	Physiological mechanisms in response of chickens to stress	Beltsville, Md.	No	
AH e3-15	Neural-pituitary functions in egg producing processes in fowl	Beltsville, Md.	Yes	9-A-1
AH e3-16	Effect of controlled photoperiods on growth and egg production	Glendale, Ariz.	Yes	9-B-1
AH e3-17	Egg production efficiency of caged and floor-housed pullets	Glendale, Ariz.	Yes	9-D-1

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Inc. in	
			Summary of Progress	Area & Sub- Subheading
AH e3	Poultry physiology investigations (continued)			
AH e3-18**	Effect of environment on reproduction in turkeys	Beltsville, Md.	Yes	9-B-1
AH e3-19**	Parthenogenesis in avian eggs	Beltsville, Md.	Yes	9-A-2
AH e3-20**	The homograft reaction and immunological tolerance in birds	Beltsville, Md.	Yes	9-A-2
AH e4	Poultry meat and egg quality as affected by nutrition, breeding, physiology and other management factors		Yes	20
AH e4-9	Effect of age, sex, breed and management on the physical, chemical and morphological characteristics of poultry skin	Beltsville, Md.	No	
AH e4-10**	Effect of breeding and management of the flock on the chemical and morphological characteristics of the yolk and yolk membrane of chicken eggs	Beltsville, Md.	Yes	20-D
AH e5	National Poultry Improvement Plan (There are no line projects under this work project)	Beltsville, Md. In cooperation with 47 Official State Agencies. (Alaska, Hawaii and Nevada not included)	Yes	8-B-2,3
AH e6	Improvement of viability of poultry		Yes	1, 11
AH e6-2	The development and maintenance of inbred lines of chickens showing a wide range of assistance and susceptibility to avian lymphomatosis	East Lansing, Michigan	Yes	11-B
AH e6-3	A research program for the production and the maintenance of susceptible chickens free of lymphomatosis	East Lansing, Michigan	No	
AH e6-10	A study of the characteristics of the causative agent of visceral lymphomatosis in the chicken	East Lansing, Michigan	Yes	11-A-1
AH e6-17	Studies on the immunity of chickens to visceral lymphomatosis	East Lansing, Michigan	Yes	11-A-2
AH e6-20	Identification of cell types found in the lesions and blood of chickens with the different forms of the avian leukosis complex	East Lansing, Michigan & AMS, Wash.	Yes	1-B-1
AH e6-21(C)	Effect of feeding cod liver oil on the occurrence of lymphomatosis in chickens	East Lansing, Michigan & Univ. of Wisc., Madison, Wisc.	Yes	11-C
AH e6-24	Propagation and characterization of the visceral lymphomatosis virus in tissue culture	East Lansing, Michigan	Yes	11-A-2
AH e6-25	The effect of environment conditions on the incidence of visceral lymphomatosis among young chickens	Reg. Poult. Lab. & Mich. State Univ., East Lansing, Mich.	No.	
AH e6-26	Studies on the anatomy of the domestic fowl including the skeletal, muscular, circulatory and nervous system	East Lansing, Michigan	Yes	1-B-1
AH e6-27**	Studies of the epizootiology of avian lymphomatosis and related neoplasms	East Lansing, Michigan	No	
AH e6-28**	A study of the genetic variability remaining in highly inbred lines of chickens	East Lansing, Michigan	Yes	11-B
AH e7**	Relation of environment and management to disease and broiler condemnations		Yes	9-D
AH e7-1**	Relation of environment and management to disease and broiler condemnations * Discontinued during report year ** Initiated during report year	State College, Miss.	Yes	9-D-2

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Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Incl. in	
			Summary of Progress	Area & Sub- Subheading
AH f1	Fur animal breeding (including rabbits)		Yes	18-A, B
AH f1-1	Genetic investigations of traits for use in breeding and selection for improvement of meat rabbits	Davis & Fontana, Calif., Beltsville, Md.	Yes	18-A-1 18-B-5,6,7
AH f1-2	Genetics of mink and marten with emphasis on mutant characters and pelt quality	Madison, Wis.	Yes	18-A-2 18-B-2,3
AH f1-3	Development of a superior strain of blue foxes	Petersburg, Alaska	No	---
AH f1-4	Marten mating systems to increase breeding regularity and prolificacy	Petersburg, Alaska	Yes	18-B-4
AH f1-6	Effect of breeding does at various intervals following kindling on the growth and weaning weight of the young and on subsequent reproductive performance of the doe	Fontana, Calif.	Yes	18-B-8
AH f2	Fur animal physiology of reproduction		Yes	18-B
AH f2-1	Effects of hormones on growth and reproduction of mink	Petersburg, Alaska, Madison, Wis.	Yes	18-B-1, 8
AH f2-3	Management factors affecting reproductive performance in mink	Ithaca, N. Y.	No	---
AH f2-4	A study of lactation in the mink	Swarthmore, Pa.	No	---
AH f3	Fur animal feeding and nutrition		Yes	18-C
AH f3-1	Development of diets based on sea fish and sea mammals and their products for blue fox, mink and marten	Petersburg, Alaska, Ithaca, N. Y.	Yes	18-C-1
AH f3-2	Relationship of nutrient factors and physical characteristics in diet to rabbit production	Bloomington & Fontana, Calif.	Yes	18-C-2
AH f3-4	Study of various proteins as rabbit feed	Davis & Fontana, Calif.	Yes	18-C-3
AH f3-5	Investigations of the basic nutrient requirements and nutrient utilization by mink	Ithaca, N. Y.	Yes	18-C-4
AH f3-6	The development of practical diets and feeding practices for mink	Ithaca, N. Y.	Yes	18-C-5
AH f4	Fur fiber and fur investigations		Yes	18-B, C
AH f4-3	The priming process in fur bearing animals	Beltsville, Md. Ithaca, N. Y.	Yes	18-C-6
AH f4-4	Influence of endocrine factors on the development of hair follicles within the skin of fur-bearing animals	Beltsville, Md. Ithaca, N. Y.	Yes	18-B-9

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Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Incl. in	
			Summary of Progress	Area & Sub- Subheading
AH g1	Genetics and interrelations of anatomical and physiological characteristics of dairy cattle		Yes	1, 5, 6, 7
AH g1-1	Genetic and phenotypic relation of body form in the growing heifer to body form and producing capacity in the cow	Beltsville, Md., Urbana, Ill., Columbus, Ohio, Lafayette, Ind., & St. Paul, Minn.	Yes	5-A-2,3,4, 6
AH g1-2	Genetic and phenotypic interrelationships between body form, internal anatomy and milk production in the cow	Beltsville, Md.	Yes	5-A-5
AH g1-3	Studies of the rate and form of mammary gland development in cattle at different ages, in relation to milk production	Beltsville, Md., St. Paul, Minn., Huntley, Mont., Columbus, Ohio, Lewisburg, Tenn., Madison, Wis.	Yes	5-A-5, 6
AH g1-4	Studies of the genetics of feed utilization in dairy cattle	Beltsville, Md., Ithaca, N. Y., Lewisburg & Jackson, Tenn., Huntley, Mont., Bozeman, Mont., Logan, Utah	Yes	5-A-1
AH g1-5	Studies of the genetics of milk constituents and other properties related to milk production	Beltsville, Md., East Lansing, Mich., Madison, Wis.	Yes	5-A-8
AH g1-6	A study involving the repeatability and standardization of blood typing in dairy cattle	Beltsville, Md., & cooperating laboratories	Yes	5-A-10
AH g1-7	The importance of immunogenetic factors in problems of lowered fertility in cattle	Beltsville, Md.	Yes	1-B-6 5-A-9
AH g1-8**	Antibodies in bovine milk	Beltsville, Md.	Yes	6-B 7-E-5
AH g2	The application of advanced genetic concepts and principles for the improvement of dairy cattle		Yes	5-C
AH g2-5	Developing and evaluating desirable production characteristics in Holstein cattle by inbreeding, outbreeding and inter-line crossing	Lake Mills & Madison, Wis.	Yes	5-C-1
AH g2-22	Studies to estimate the relative importance of general and specific combining ability in relation to breeding dairy cattle	St. Paul, Minn., Columbus, Ohio	Yes	5-C-2
AH g2-23	Studies to evaluate the amount and usefulness of heterosis resulting from interbreed matings of dairy cattle	Beltsville, Md., Urbana, Ill., & Farmland, Ind.	Yes	5-C-3
AH g2-24	The influences of parental relationship on the genetic merit of dairy sires and cows	Beltsville, Md.	Yes	5-C-4
AH g2-25	The value of the continuous use of progeny tested sires and sons of progeny tested sires for improving dairy cattle	Beltsville, Md.	Yes	5-C-5
AH g2-26	Comparisons of genetic methods of using sires available in artificial breeding of dairy cattle	St. Paul, Minn.	No	---
AH g2-27	A comparison of selection for milk production with selection for total fat production in dairy cattle	Cortland, N. Y.	No	---
AH g3	Investigations of dairy herd management		Yes	7
AH g3-7*	The detection of antibiotics in milk	Beltsville, Md.	Yes	7-E-4
AH g3-8	Evaluation of management practices for the control of bovine mastitis	Beltsville, Md.	Yes	7-E-3
AH g3-9*	Hand vs. machine milking	Beltsville, Md.	Yes	7-E-1

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Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Incl. in	
			Summary of Progress	Area & Sub- Subheading
AH g3	Investigations of dairy herd management (continued)			
AH g3-10	Electrically controlled and operated equipment for reduction of labor in dairy production	Beltsville, Md.	Yes	7-E-2
AH g3-12**	Evaluation and development of equipment and physical methods for control of flies and other dairy cattle pests	Beltsville, Md.	No	
AH g4	Factors influencing dairy cattle adaptability		Yes	5, 6, 7
AH g4-1	Relationship of anatomical and physiological characteristics to dairy cattle adaptability	Beltsville, Md., Tifton, Ga., Baton Rouge, Homer & Jeanerette, La., College Station, Texas	Yes	6-A-3 6-D-1,2,3, 4,5,6
AH g4-2	Genetic methods for developing adaptability of dairy cattle to hot and/or humid regions	Tifton & Reidsville, Ga., Baton Rouge, Homer & Jeanerette, La., College Station, Texas	Yes	5-C-6
AH g4-3	The influence of management practices and other environmental factors on adaptability of dairy cattle to hot and humid regions	Tifton, Ga., Baton Rouge, La., College Station, Texas	Yes	7-E-6
AH g5	Evaluation of concepts for procurement, interpretation and use of dairy herd records		Yes	7-E-7
AH g5-1	Studies on methods for minimizing environmental influences on production records of individual cows and progeny records	Madison, Wis., Beltsville, Md., College Park, Md.	Yes	7-E-7
	* Discontinued during report year.			
	** Initiated during report year.			

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Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Incl. in	
			Summary of Progress	Area & Sub- Subheading
AH h1	The nutritional factors affecting normal growth and health of calves and growing cattle		Yes	6, 7, 1
AH h1-1	Wilted alfalfa silage as a forage for growing dairy heifers	Beltsville, Md.	Yes	7-D-1,2,3, 4,5
AH h1-2*	A study of magnesium deficiency in calves and a nutritional imbalance associated with milk diets	Beltsville, Md.	Yes	7-D-6,7
AH h1-3*	A study of vitamin and mineral requirements and deficiency symptoms using a synthetic type of diet with dairy calves	Beltsville, Md.	Yes	6-C-3 7-D-8,9
AH h2	A study of nutritional and related factors affecting the usefulness of producing dairy cattle		Yes	1, 7
AH h2-3	Microbiology of the bovine rumen	Beltsville, Md.	Yes	1-D
AH h2-4*	A study of the dry matter and TDN maintenance requirement of dairy cows and the causes of their variation	Beltsville, Md.	Yes	7-C-1,2, 3,5
AH h2-5	Factors involved in the efficiency of forage utilization by dairy heifers	Bozeman, Mont.	No	
AH h2-6	Development and use of chemical methods for determining the nutritive values of dairy feeds and forages	Beltsville, Md.	Yes	7-A-5
AH h2-7	The measurement of heat production of grazing cattle	Beltsville, Md.	Yes	7-C-4
AH h2-8	Determination of the nutritive value of cattle feeds by calorimetric methods	Beltsville, Md.	Yes	7-A-1,2, 3,4
AH h2-9**	Extent to which agricultural chemicals are secreted into milk	Beltsville, Md. Tifton, Ga	Yes	7-A-6,7
AH h2-10(C)**	A study of nutritional and related factors affecting the usefulness of dairy cattle	Beltsville, Md. Ithaca, N. Y	No	
AH h3	Studies on the management, preservation and utilization of grassland crops for dairy cattle		Yes	7
AH h3-1	A biochemical study of the ensiling of forage crops	Beltsville, Md.	Yes	7-B-1
AH h3-2*	A microbiological study of silage made from grassland forage	Beltsville, Md.	Yes	7-B-1
AH h3-3	A study of the effects of kinds of crop, kinds of treatment, methods of handling and conditions of storage of forage on the resulting silages and the production of silages suitable for fundamental bacteriological and biochemical studies	Beltsville, Md.	Yes	7-B-1
AH h3-6	Nutritive value of pasture species in the Puget Sound area for dairy cattle	Puyallup, Wash.	No	
AH h3-7	Preservation and nutritive value of silages produced in the Puget Sound area as affected by method of harvesting and preservation and type of silo	Puyallup, Wash.	Yes	7-B-1
AH h3-8	Comparison of upright and bunker type silos for preserving nutrients of silage crops	Willard, N. C.	Yes	7-B-1
AH h3-9	A study of practical ensiling procedures and evaluation of resulting silages with dairy cattle	Lewisburg, Tenn.	Yes	7-B-1
AH h3-10	Evaluation of Coastal Bermuda Grass for lactating dairy cows	Willard, N. C.	Yes	7-B-2
AH h3-11	Development of feeding system for raising dairy calves using available roughages and limited quantities of milk and concentrate	Willard, N. C.	Yes	7-D-10
AH h3-12	Investigation of factors affecting forage production of Tennessee grasslands for dairy cattle	Lewisburg, Tenn.	No	
AH h3-17	The relation of date of cutting and dry matter content when cut to digestibility, consumption and acre nutrient yields of forage crops	Huntley, Mont.	No	
AH h3-18	The effect of varying stocking rates on nutrient yields per acre of orchardgrass-ladino clover pastures and on production per animal of dairy cows grazing these pastures	Beltsville, Md.	Yes	7-B-2

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Inc. in	
			Summary of Progress	Area & Sub- Subheading
AH h4	Bioassay of nutritional requirements and processes of dairy cattle		Yes	1
AH h4-1	Unidentified nutrients in milk, milk products and related foods and feeds	Beltsville, Md.	Yes	1-C-3
AH h4-3	The metabolic function of vitamin B ₁₂	Beltsville, Md.	Yes	1-C-1
AH h4-4	Production of vitamin B ₁₂ by microorganisms of the bovine rumen	Beltsville, Md.	Yes	1-C-2
AH h5	Physiological studies of reproduction, mammary gland growth and lactation in dairy cattle		Yes	1, 6
AH h5-1	Hormonal and nutritional aspects of mammary growth and lactation	Beltsville, Md.	Yes	1-B-6 6-B 6-D-3
AH h5-2	Development of methods for the determination of secretion rate and metabolism of hormones in dairy cattle	Beltsville, Md.	No	
AH h5-3	Physiological mechanisms related to reproductive performance of dairy cattle	Ithaca, N. Y. Beltsville, Md.	Yes	6-A-2,3,4 6-G-1,2
AH h5-4	Pre- and post-ovulatory factors affecting fertilization and embryonic survival in dairy cattle	Amherst, Mass.	Yes	6-A-1,5
AH h5-6	Physiological bases for variations in fertilization success and embryo survival that may be associated with lowered fertility in dairy cattle	Madison, Wisc.	Yes	6-A-1 1-B-4,5
AH h5-8**	Endocrine influences on embryonic mortality and uterine physiology	Beltsville, Md.	Yes	1-B-2,3
	* Discontinued during report year.			
	** Initiated during report year.			

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			Summary of Progress	Area & Sub- Subheading
AH i4**	Dairy herd improvement research through analysis of data collected in National Cooperative Dairy Herd Improvement and Sire-Proving Programs and the development of effective production testing organizations		Yes	5-B
AH i4- 1**	Research on the evaluation of superior sires and cows in the national dairy herd and on the factors affecting these estimations	Beltsville, Md. All 50 States	Yes	5-B-1
AH i4- 2**	Analysis of different types of records of performance and breeding society organizations, testing plans, methods and forms used in collecting and evaluating production records to improve the effectiveness of DHIA sire-proving and related programs	Beltsville, Md. All 50 States	Yes	5-B-2
AH i4- 3**	Analysis of DHIA cow and herd production records to determine from year to year the relationships between yield, feed inputs, costs, and related factors	Beltsville, Md. All 50 States	Yes	5-B-3
	** Initiated during report year			

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			Summary of Progress	Area & Sub- Subheading
AH j1	Humane slaughter of meat animals		Yes	20
AH j1-1	Methods suited to small packing plants for using carbon dioxide and other cases of induced anesthesia in swine, sheep and calves prior to slaughter	Ithaca, N. Y.	Yes	20-F-1
AH j1-2	Humane slaughtering techniques as they influence procedures and quality of meat	Beltsville, Md.	Yes	20-F-2
AH j1-3**	Electrical stunning as a method of inducing anesthesia in humane slaughtering of meat producing animals	St. Paul, Minn.	Yes	20-F-3
	** Initiated during report year			

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			Summary of Progress	Area & Sub-Subheading
AH P-1	Pioneering laboratories	Beltsville, Md.	Yes	1-A-2
AH P-2	Pioneering Blood Antigen Laboratory	Lafayette, Ind.	Yes	1-A-1
	Pioneering Research Laboratory in Basic Animal Genetics			
BS 3-34	Projects delegated to AH by AMS	Beltsville, Md.	Yes	20-A-2
	Objective methods for estimating the composition of live meat animals			20-B-2
				20-C-2
BS 3-102 **	Objective methods for evaluating the market quality of livestock and meat	Beltsville, Md.	No	
A7-AH-1**	PL 480 Projects	Izatnagar, U. P. India	No	
	Physiology and genetics of characteristics influencing the adaptability of cattle and buffalo for dairy production in India; genetic methods for developing adaptability; and the effect of climatic elements and other environmental influences on adaptability			
A7-AH-11**	Factors affecting the utilization of low-grade roughages and production of volatile fatty acids in the rumen of cattle	Punjab, India	No	
A10-AH-7**	Utilization and function of vitamin A in the nutrition of poultry	Rehovoth, Israel	No	
E8-AH-1	Breed differences regarding the antigenic properties of cattle blood, their inheritance in relation to economic characteristics and genetic origin of the breed	Tikkurila, Finland	Yes	5-A-10
E21-AH-1	Secretion of anterior pituitary hormones and ovulation in small ruminants	Warsaw, Poland	No	
E21-AH-2	Color in pork as influenced by heredity, sex, age, feeding and management of animals	Warsaw, Poland	Yes	20-C-3
E21-AH-4**	Investigations of blood groups in a new racial group of the "Zlotnicka pig"	Poznan, Poland	No	
E21-AH-5	Protein compounds of vitamin B ₁₂ and its analogs	Poznan, Poland	No	
E25-AH-4**	Contribution to the study of metabolism of zinc in living organisms by means of zinc 65	Madrid, Spain	Yes	1-C-5
S3-AH-7**	Structural and physiological characteristics associated with adaptability of cattle in tropical and sub-tropical areas	Sao Paulo, Brazil	Yes	6-D-7
S5-AH-1**	The evaluation of the native breed, Costeno Con Cuernos, and European breeds and European-native breed crosses when managed and selected for dairy cattle traits under the hot and humid conditions of Northern Colombia	Bogota, Colombia	Yes	5-C-6
	* Discontinued during report year			
	** Initiated during report year			